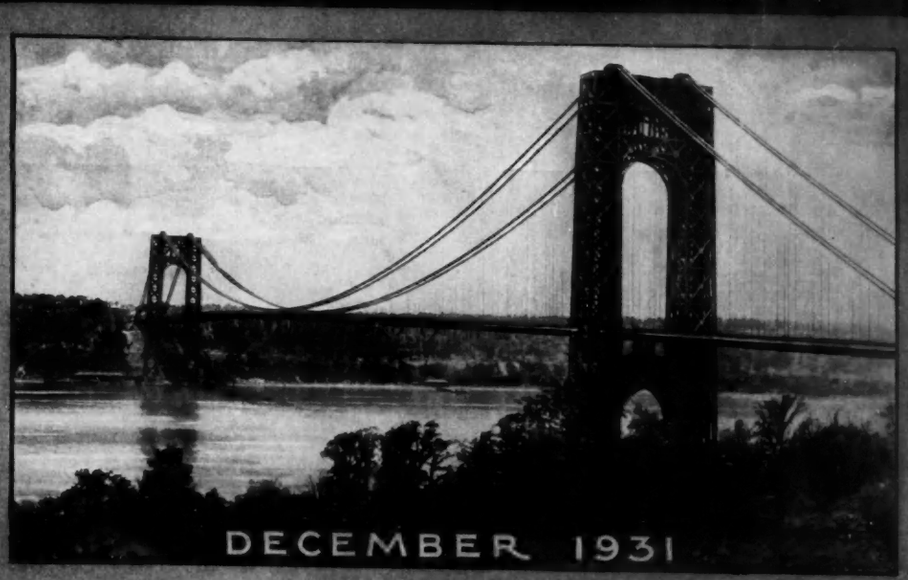
# S·A·E JOURNAL



DECEMBER 1931

**Complete Freedom from "Boulevard Jiggle"**

**Plus the Utter Softness of Ride Produced By**

## WATSON RUBBER INTERLEAVES

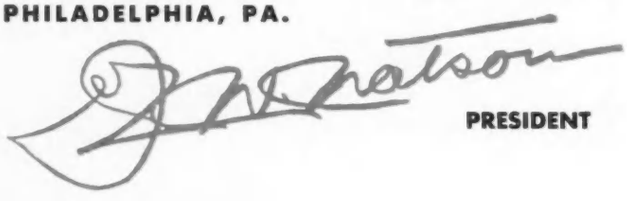
**Will be made Fully Available By the Infallible**

**Control Action of**

# GYRO

**FIRM AGAINST SIDE SWAY**

**JOHN WARREN WATSON COMPANY**
**PHILADELPHIA, PA.**



**PRESIDENT**

# S·A·E· JOURNAL

*Published by the* SOCIETY OF AUTOMOTIVE ENGINEERS, INC., 29 *W. 39th St., New York*
*Cable Address:* AUTOENG *Telephone:* LONGACRE 5-7170

VINCENT BENDIX, *President* | JOHN A. C. WARNER, *Secretary* | C. W. SPICER, *Treasurer*

Vol. XXIX | December, 1931 | No. 6

## CONTENTS

*General Design and Research*

Instrumentation as a Means of Coordinating Chassis and Body Design—A. F. Denham 442

Fuel-Line Temperatures in Cars of 1931—Oscar C. Bridgeman and Hobart S. White 447

Practical Experiences with Devices for Damping Torsional Vibrations—Erich Sandner and J. Barraja-Frauenfelder 458

Some Primary Causes of Automobile Accidents—Victor M. Killick 470

Automotive Research—Graphical Determinations of Streamline Curves 479

Standardization Progress 480

Notes and Reviews 490

*Production Engineering*

Heat-Treating Methods and Costs—Ernest Foster Davis 474

Gaging to 0.00001 In. 482

*Transportation Engineering*

Transport Engineers Meet President Hoover 423

Some Problems of the Motor-Transportation Executive—T. L. Preble 431

Summary of 1931 Motor-Truck Legislation—Pierre Schon 435

*Aeronautic Engineering*

The Turbo Supercharger—Discussion of the A. L. Berger and Opie Chenoweth Paper at the 20th National Aeronautic Meeting 476

A Study of Airplane and Instrument-Board Vibration—Discussion of Stephen J. Zand's 20th Aeronautic Meeting Paper 477

*News of the Society*

Gala Event Promised by Dinner Committee 428

Annual Meeting in Detroit, Jan. 25-29 429

Chronicle and Comment 430

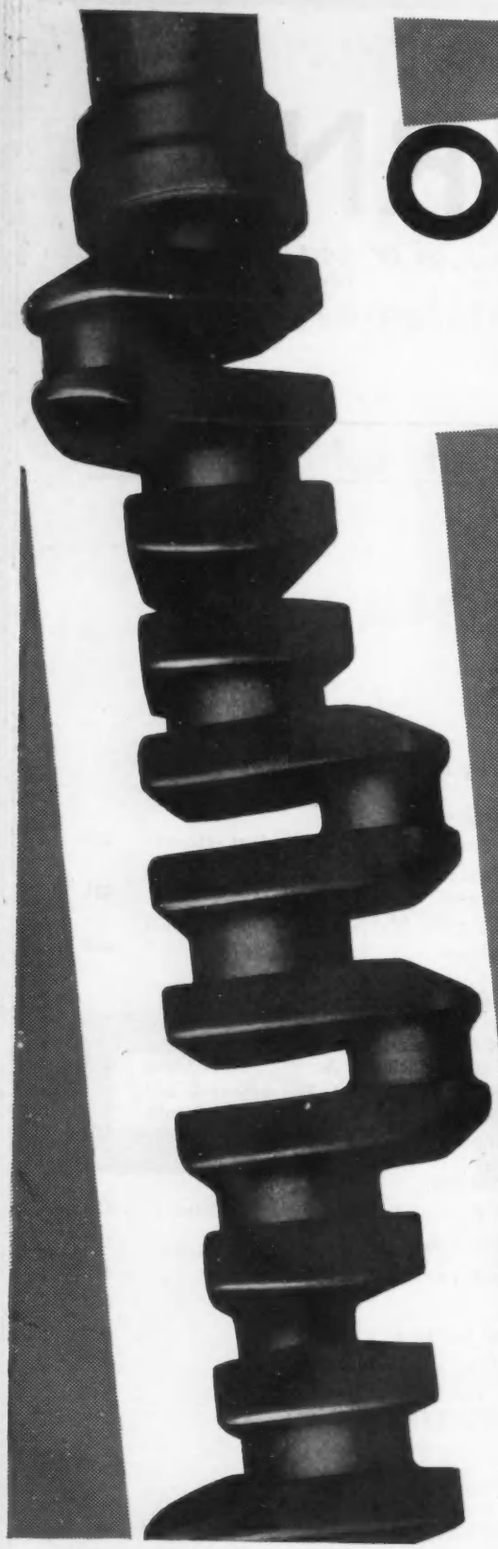
Obituaries 481

News of the Sections 484

Personal Notes of the Members 488

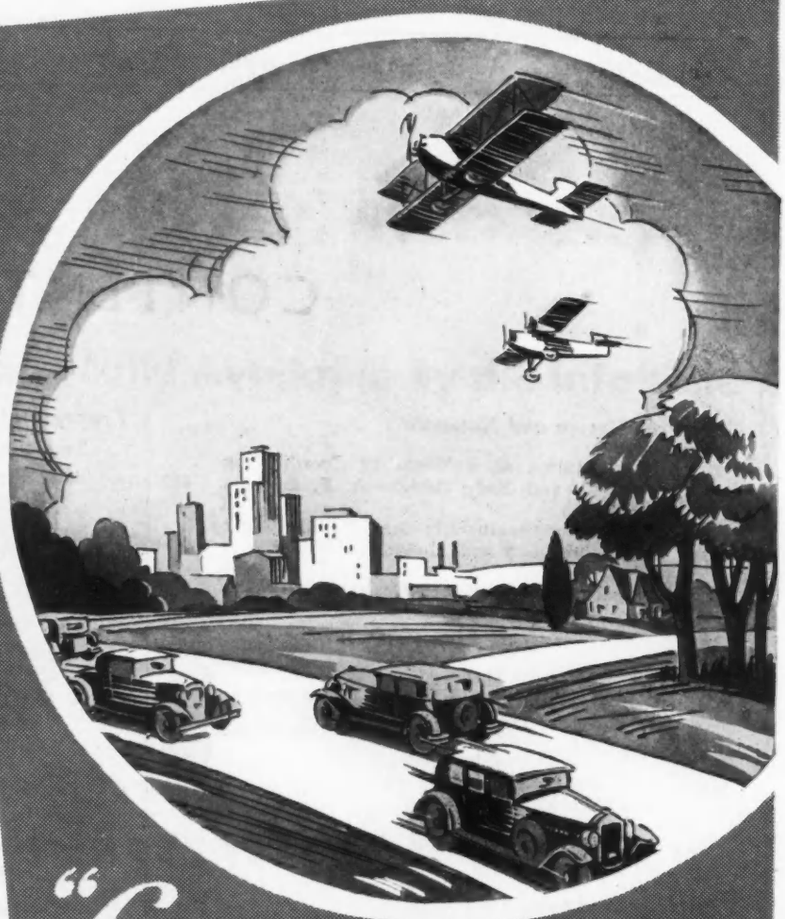
Applicants for Membership 489

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.



# ON THE AIRWAYS TODAY

*as on the highways for the last 30 years!*



*"Guaranteed Forgings"*

# WYMAN-GORDON

Worcester, Mass. *and* Harvey, Ill.

S·A·E·JOURNAL

Published by the Society of Automotive Engineers, Inc.

December, 1931

Vol. XXIX, No. 6

# Transport Engineers Meet President Hoover

## *National Transportation Meeting Provides a Variety of Exceptional Attractions*

ONE OF THE MOST popular events of the 9th National Transportation Meeting, held in the City of Washington Oct. 27 to 29 inclusive, was a visit with President Hoover, who offered his hearty commendation and best wishes to our members. Three days were crowded to overflowing with engineering discussions ranging from studies of transportation costs to chassis and body design, lubrication problems. Diesel-engine applications, legislative activities, railroad and highway-transportation coordination and responsibilities of the transportation executive. Inspection trips were made to the plant of the Washington Railway & Electric Co. and to the Bureau of Standards in buses provided by courtesy of the Capital Traction Co. through E. S. Pardoe, superintendent of bus operations. The National Transportation Dinner which climaxed the meeting was addressed by W. R. Smith, president of the American Road Builders Association. William P. MacCracken, Jr., very ably filled the rôle of toastmaster, and Roe Fulkerson provided the humorous fare of the dinner.

Many members expressed great appreciation to Vice-Presidents F. K. Glynn and L. R. Buckendale, who, with their Activity Committees, were largely responsible for the success of the undertaking. Vice-President Glynn took occasion, at the dinner, to thank the Washington and Baltimore Sections for their able cooperation in many phases of the arrangements. He mentioned specifically the assistance generously given by Adrian Hughes, Jr., B. B. Bachman, C. S. Bruce, G. K. Burgess, H. C. Dickinson, R. D. Voshall, Augustus Gumpert, of the Washington Convention Bureau, E. S. Pardoe, G. O. Pooley, William P. MacCracken, Jr., A. B. Boehm, C. S. Fliedner, the speakers and chairmen, the Activity committeemen, the Bureau of Standards, the Washington Railway & Electric Co. and others.

Honor guests at the Speakers' Table at the Transportation Dinner included Adrian Hughes, Jr., B. B. Bachman, A. J. Scaife, A. H. Gossard, Gen. John L. DeWitt, L. R. Buckendale, Roe Fulkerson, William P. MacCracken, Jr., W. R. Smith, F. K. Glynn, Lieut.-Col. C. M. Wesson, Pyke Johnson, Col. E. S. Stayer, A. S. McArthur and C. S. Bruce.

### Executive's Problems Ably Discussed

With F. K. Glynn, Chairman of the Transportation and Maintenance Committee, presiding, the first session of the meeting was opened by the presentation by T. L. Preble of his paper on Some Problems of the Motor-Transportation Executive. Mr. Preble's paper is printed in full in this issue of the S.A.E. JOURNAL, beginning on p. 431.

Both the author and the Society were warmly congratulated upon the character and quality of the paper by many discussers, who agreed with Mr. Preble on nearly all of his statements and suggestions. L. V. Newton, of the Byllesby Engineering & Management Corp., expressed the belief that the reason that some transportation superintendents have not been successful is that they could not show their superiors exactly what they had accomplished or were trying to do because they did not have a cost-analysis system or did not know how to use it. Those who entrust men with supervision of their transportation are interested only in how well the job is done and how much it costs. Since October, 1929, very high pressure has been applied to effect economies and get the transportation work done cheaper and better than ever before. Even when we emerge from the depression, the transportation man must be alert to hold the costs at the new low levels, and that will make his job still more important.

Alfred F. Coleman, of the Standard Oil Co. of New York, said that if the transportation executive does not have a plan for the development of his organization and the cutting down of costs he will arrive nowhere; and, even with such a plan, he must have the absolute backing of his boss.

Emphasis was placed by A. H. Gossard, of the Middle West Utilities Co., upon salesmanship and the control of transportation. The centralized system is ideal if it will work, but he is becoming more and more sold on a decentralized system. Many of the important items listed by Mr. Preble as necessary for a centralized system apply as well to a decentralized system. Mr. Gossard believes that legislation has caused more changes in design in the last year than any other factor.

Speaking as a vehicle owner, A. B. Pymer, of the Rice Bakery Co., referred to the importance of the manufacturers' executives getting out in the field to know what is needed. Because

truck companies do not build light delivery wagons suitable for a maximum load of 750 lb. that have to make 350 to 400 stops and starts per day, bakers must take or leave trucks built to haul heavy sand, meat or milk.

Thorough agreement with Mr. Preble's exposition of the advantages of centralized control was voiced by J. A. White, of Mack Trucks, Inc., who confidently expects them to work out in practice with any company that adopts the system. One possible disadvantage is the danger of too much concentration of authority in the hands of an expert who will become so overloaded with details that conditions in remote territories will not receive sufficient consideration.

A. J. Scaife, of the White Motor Co., remarked that the problem of the engineer and the manufacturer is to find out what the customer wants a vehicle to do and then suit the vehicle to the need. The lack has been that vehicles have been built to suit the ideas of the engineers and the manufacturers rather than the job.

A suggestion that representative railroad officials be included in the committee recommended by Mr. Preble was made by F. C. Horner, of the General Motors Corp. While recommendations of the transportation executive should, to a very large extent, influence the decision as to purchases of equipment, the actual buying should be done by the purchasing agent. An important item that might be included in the questionnaire is traffic conditions.

J. M. Orr, of the Equitable Auto Co., remarked that, in fairness to the seller, the buyer should have a well-defined idea of the requirements and the operating conditions that the vehicles have to meet. If the buyer makes a mistake in selection of a unit, he has to live with it for several years.

# Meetings

## National Meetings

**Miami Air-Race Dinner—Jan. 6**

In cooperation with the City of Miami Chamber of Commerce and the Aeronautical Chamber of Commerce of America

**Annual Dinner—Jan. 14**

Pennsylvania Hotel, New York City

**Annual Meeting—Jan. 25 to 29**

Book-Cadillac Hotel, Detroit

**21st National Aeronautic Meeting—April 5 and 6**

Detroit

## Section Meetings

**Baltimore—Dec. 10**

Hotel Emerson; Dinner 6:30 P.M.

Cooperative Aeronautic Meeting with Aeronautical Chamber of Commerce of America

Reducing Aircraft Accidents — Lieut. Carl B. Harper, U.S.N., Retired

**Buffalo—No Meeting**

**Chicago—Dec. 1**

Sherman Hotel; Dinner 6:30 P.M.; Entertainment

Some Phases of Highway Transportation —A. J. Scaife, Consulting Field Engineer, White Motor Co.

Practical Trailer Transportation — Motion picture to be shown by R. B. Jones, Chief Engineer, Trailer Company of America

**Cleveland—Dec. 14**

Cleveland Club; Dinner 6:30 P.M.

Joint Meeting with the American Society for Steel Treating

The Joining of Metals—L. D. Meeker, Manager, Welding Sales, General Electric Co.

Oxy-Welding and Cutting—Motion picture from the Linde Air Products Co.

**Dayton—Dec. 8**

Engineers Club of Dayton; Dinner 6:30 P.M.

John Public's Airplane — William B. Stout, President, Stout Engineering Laboratories

**Detroit—Dec. 7**

Book-Cadillac Hotel; Dinner 6:30 P.M.

Aeronautic Meeting 5:15 P.M. — Diesel Engines in Aircraft—E. T. Vincent, Diesel Research Engineer, Continental Motors Corp.

Regular Meeting 8:00 P.M.—Air Transport Ignores the Depression—Carl B. Fritsche, President, Aircraft Development Corp.

**Indiana—Dec. 10**

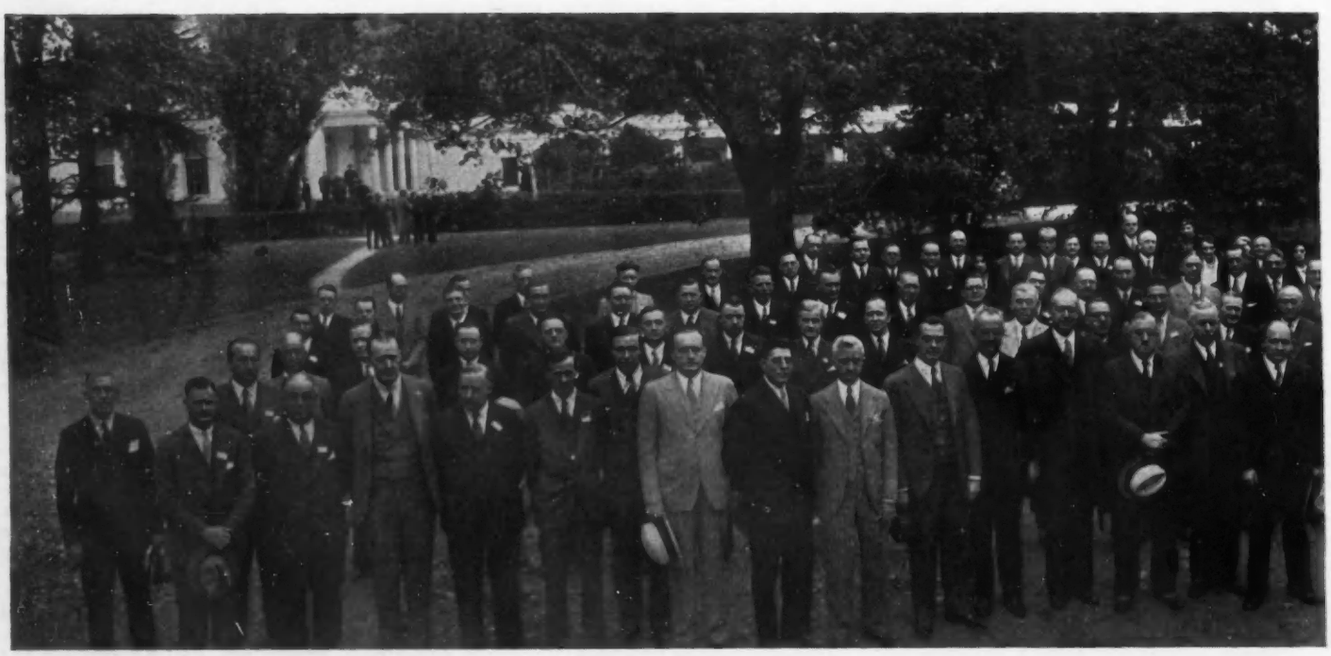
Hotel Severin, Indianapolis; Dinner 6:30

Recent Developments in Transmissions—Samuel O. White, Chief Engineer, Warner Gear Co.

**Kansas City—Dec. 11**

Door-to-Door Delivery—A. H. Gossard, Vice-President, Middle West Utilities Co.

Changes in Tire-Servicing Problems—J. W. Shields, Field Engineering Department, Firestone Tire & Rubber Co.



PRESIDENT HOOVER AND ATTENDANTS AT THE TRANSPORTATION MEETING PHOTOGRAPHED ON THE

# Calendar

**Metropolitan—Dec. 17**

A.W.A. Clubhouse, 357 West 57th Street, New York City; Dinner 6:30 P.M.

Diesel Engines — Prof. M. S. Huckle, Massachusetts Institute of Technology

Discussion of Two-Cycle Engine Which Constituted Powerplant of Elmore Car —H. L. Newton, Vacuum Oil Co.

**Milwaukee—Dec. 2**

Milwaukee Athletic Club; Dinner 6:15 P.M.

Joint Meeting with the Milwaukee Post, Army Ordnance Association.

Automotive Equipment in the Army—Major L. H. Campbell, Rock Island Arsenal

The Russian Situation — L. J. Kanitz, Sales Manager, Continental Motors Corp.

**Northwest—Dec. 4**

New Washington Hotel, Seattle; Dinner 6:30 P.M.

Diesel Engines—James H. Frink, Washington Iron Works

High-Speed Ignition—Reese Lloyd, Superintendent, Sunset Electric Co.

**Oregon—Dec. 4**

Multnomah Hotel, Portland; Dinner 6:30 P.M.; Entertainment

New Method of Adjusting Carbureters by Exhaust-Gas Analysis—Prof. S. H. Graf, Director of Engineering Research, Oregon State College

Mineral Lubricating Oils, Their Productive Properties and Reclamation—S. C. Schwarz, Chief Chemist, Portland Gas & Coke Co.

Diesel Engines — Prof. F. G. Baender, Department of Mechanical Engineering, Oregon State College

Also a short talk on Safety by a well-known authority

**Pittsburgh—Dec. 1**

Pittsburgh Chamber of Commerce; Dinner 6:30 P.M.; Entertainment

Joint Meeting with Aeronautical Chamber of Commerce of America

Aluminum Construction as Applied to the U.S.S. Akron — G. O. Hoglund, Aeronautic Engineer, Aluminum Co. of America

Engineering and Its Relation to Aviation — D. W. Tomlinson, Vice-President and General Manager, Transcontinental & Western Air

Developments in Aviation — William B. Stout, President, Stout Engineering Laboratories, Inc.

**Southern California—Dec. 4**

Elks Club, Los Angeles; Dinner 6:30 P.M.

Improvements in Pneumatic Truck Tires—H. D. Tompkins, Sales Manager, Firestone Tire & Rubber Co.

Rim Standardization — W. D. Smith, Manager, Motor Rim & Wheel Service

Service Analysis—Doc Day, Service Manager, Goodyear Tire & Rubber Co.

T. C. Smith, of the American Telephone & Telegraph Co., stated that he has received excellent cooperation from manufacturers' executives, engineering staffs, sales engineers and salesmen. With reference to centralized control, he said that the best thing the man in authority can do when he approaches one of the units of the organization is to forget his authority.

### Rail and Road Transport Coordination and Regulation

In his paper on the Coordination of Railway and Highway Transportation, S. O. Dunn, editor of *Railway Age*, dealt in Tuesday afternoon's session with the highly controversial subject of uniformity of taxation and regulation of the railroads and motor-vehicles as a requisite to coordination. An abstract of the paper was printed in the S.A.E. JOURNAL for November, p. 349. The session was convened by A. S. McArthur, of the Toronto Transportation Commission, and E. S. Pardoe, of the Capital Transportation Co., presided.

In the second paper of the session, Pierre Schon, of the General Motors Truck Co., told of legislative activities in 1931 with regard to motor-trucks, the wide variations in legal restrictions and the effect that they are having on design and operation. This paper also was summarized in the November issue.

Discussion was almost wholly on Mr. Dunn's paper and, while some speakers agreed with the fundamental principles as regards equality of opportunity afforded the railroads and highway transportation, they disagreed with him on facts of taxation and regulation. F. J. Scarr, of the Scarr Transportation Service, cited testimony by Thomas H. MacDonald, of the Bureau of Public Roads, that "approximately 81.9 per cent of the total income for State high-

WHITE HOUSE LAWN DURING THE PRESIDENT'S RECEPTION OF THE MEMBERS OF THE SOCIETY

ways is coming from the road users." Even if highway-transportation taxes were doubled, they are such a small proportion of the operating expenses that the relations of railroad and highway transportation would not be fundamentally changed. He also remarked that highway transportation is not now handling its economic proportion of the volume of available freight and that any increase in railroad freight rates that may be granted by the Interstate Commerce Commission will throw that much more freight over to highway transportation.

An important point made by A. J. Scaife is that the railroad right-of-way is used exclusively by it, whereas the public highways are most extensively used by private automobiles. Moreover, 82 per cent of motor-trucks are privately owned by persons who pay taxes for construction of the roads over which they operate their trucks carrying their own products. Railroad regulation was the penalty demanded by the public for abuses and, if similar abuses arise in motor transport, the public undoubtedly will demand its regulation. The public will decide what forms of transportation it desires to use. It will not do to attempt to combine rail, highway and air transportation facilities, as the services rendered are based on entirely different demands.

H. S. Fairbanks, of the Bureau of Public Roads, pointed out that of 3,000,000 miles of highway, only one-tenth are main roads on which traffic is in competition with the railroads, while that on the local roads feeds traffic to the railroads, and nearly 90 per cent of current taxation receipts for construction and maintenance of the main roads comes from motor-vehicles.

Competition with which the railroads are confronted is due to the desire of the public to have transportation "on tap", according to F. C. Horner. Some railroad officials have shown a great deal of vision in adopting motor transport and applying it scientifically and intelligently to their requirements. Since the handing down of the Interstate Commerce Commission decision in the so-called "container case," five car-forwarding companies owned by the railroad companies are doing a great deal of trucking up to 300 miles, and in some cases up to 500 miles. He referred to the recent inauguration of free store-door delivery by southwestern railroads as an attempt to recover traffic from the independent truck operators.

With reference to Mr. Schon's paper, F. K. Glynn said that the Society always has kept out of legislative matters but the legal restrictions on motor-vehicles should be based on sound engineering and an attempt should be made to bring into line with the Society the various organizations with and through which it must work. He believes the membership is more than ever ready individually to bring pressure to bear to secure some uniformity in State laws.

### Diesel Discussion Overflows Session

Two papers presented at the Wednesday morning session were of so much interest that some of the discussion of them had to be deferred to the evening session.

The Commercial Application of Diesel Engines in Heavy-Duty Motorcoaches and Trucks was the subject treated by George A. Green, of the General Motors Truck Corp., who reported, with the aid of numerous charts, the results of extensive tests in which the performances of a leading British six-cylinder automotive Diesel engine and a General Motors gasoline motorcoach engine of nearly the same size were compared in the laboratory and on the road in a 29-passenger motorcoach.

Curves for maximum horsepower and torque of the 495-cu.-in. Diesel engine and 525-cu.-in. gasoline engine were plotted on the same chart, and another chart reproduced, for fair comparison, the same data with curves for the gasoline engine lowered in proportion to the difference in piston displacement. Then followed a chart on which the curves of the Diesel engine were lowered to represent the maximum output at which the Diesel engine would not smoke. This thoroughness was characteristic of the score of charts and other illustrations shown.

Road tests conducted at the General Motors Proving Ground showed that acceleration and hill-climbing were much better with the gasoline engine, while fuel consumption at moderate speeds was lower with the Diesel.

The author's conclusion was that fuel economy can be obtained with a Diesel if operators will be satisfied with decidedly lower acceleration than they now demand, but that this advantage would be reduced if the engine were large enough to give performance that is satisfactory to the public. He believes that the Diesel will show up better in city than in interurban work and is better suited to electric than to mechanical transmission. A motion picture was presented to show the amount of smoke emitted by this Diesel engine under conditions of gear-changing and high-speed driving.

### Wherein Diesels Show Superiority

A. A. Lyman, of the Public Service Coordinated Transport of New Jersey, adduced evidence that numbers of Diesel-powered motorcoaches are operating with great savings in fuel. He quoted an oil-company engineer to show that the cost of Diesel fuel is never likely to be as high as that of gasoline, because of the less stringent limits required. He also said that, in the precombustion-chamber engine with which his experience was gained, not more than 5-per-cent sacrifice in power is needed to prevent smoking. Colonel Green replied to the remarks on fuel by saying that gasoline can be made from gas oil but not gas oil from gasoline.

Julius Kuttner, of Oberhaensli & Cie., presented lantern slides of tachographic records and other data from European tests on six Diesel and six gasoline engines showing the average acceleration and mean effective pressure to be better with the Diesel engines. He pointed out the advantage of turbulence in them and counselled building Diesel roofs on the highly developed structures of heavy-duty gasoline engines.

H. L. Horning also attributed the smoke in the Diesel tested by Colonel Green to lack of organized turbulence and said that surprising results could be attained in a gasoline engine if users would pay what a Diesel engine costs. A cross between the two may be the result.

### Scaife on Chassis Lubrication

Reports on experiences and suggestions from several fleet operators; manufacturers of vehicles, engines and lubricants and trade-paper editors were digested in the paper on Chassis Lubrication by A. J. Scaife, of the White Motor Co., nominee for President of the Society for 1932. This paper, which was abstracted in the S.A.E. JOURNAL for November, p. 350, was presented at the morning session and supplemented in the evening by a film prepared jointly by the Bureau of Mines and the Standard Oil Co. of Indiana to emphasize the number of lubricants required on the modern motor-car chassis.

Discussion brought out the idea that, while the requirements for multiplicity of lubricants had been a logical development, further steps in design might eliminate the need. One suggestion was that a long bearing on the water-pump might be cool enough at the outer end so that ordinary grease would not melt and flow into the water system. Another was for a division of lubrication studies among the S.A.E., the A.S.M.E. and the recently organized Society of Rheology, which should point the way toward rational analysis of flow relations and the substitution of the concept of rheologically similar materials for that of Saybolt numbers for plastic substances.

Agreement seemed to be general that designers should try to simplify the problem and that the Society should assist. Among the discussers were Winslow H. Herschel, of the Bureau of Standards; J. F. Winchester, of the Standard Oil Co. of N. J.; L. V. Newton, of the Byllesby Engineering & Management Corp.; M. C. Horine, of the International Motor Co.; A. S. McArthur, of the Toronto Transportation Commission; A. W. Scarratt, of the International Harvester Co.; Clinton Brettell, of R. H. Macy & Co; and Mayo D. Hersey, of the Vacuum Oil Co.

### Work of the Bureau of Standards

Dr. George K. Burgess, director of the Bureau of Standards, was scheduled as the speaker at the Wednesday evening session; but, as sudden illness prevented his presence, his paper was read by Dr. Lyman J. Briggs, assistant director. Flowers and a message of sympathy were sent to Dr. Burgess.

One of the points emphasized in the paper was the cooperation of the Bureau with trade and technical associations, and a communication from the Federal Trade Commission was read to show that the cooperative standardization work had its cordial approval.

It is not practicable for the Bureau

SESSION CHAIRMEN AND AUTHORS OF PAPERS PRESENTED AT THE TRANSPORTATION MEETING

(1) F. K. Glynn, American Telephone & Telegraph Co., Chairman of First Session. (2) T. L. Preble, S.P.A. Truck Corp., Who Discussed Some Problems of the Motor Transportation Executive. (3) E. S. Pardoe, Capitol Transportation Co., Chairman of Second Session. (4) S. O. Dunn, Editor of *Railway Age*, Who Spoke on Coordination of Railway and Highway Transportation. (5) Pierre Schon, General Motors Truck Co., Who Presented a Paper on Truck Legislative Activities of 1931. (6) A. J. Poole, Bendix Aviation Corp., Chairman of Wednesday Morning Session. (7) G. A. Green, Who Spoke on the Commercial Application of Diesel Engines in Motor-Vehicles. (8) A. J. Scaife, Who Urged the Need for Chassis-Lubrication Systems That Will Require Fewer Lubricants. (9) C. S. Bruce, Bureau of Standards, Chairman of Wednesday Evening General Session.

(10) Dr. G. K. Burgess, Director of the Bureau of Standards, Whose Paper on What the Bureau Is Doing for Business Was Presented by Dr. Lyman J. Briggs. (11) W. J. Cumming, Surface Transportation Corp. of New York, Chairman of Thursday Morning Session. (12) W. C. Naegel, Bender Body Co., and (13) G. H. Scragg, Mack Trucks, Inc., Authors of Two Papers on Relations of Motorcoach Chassis and Body.

(14) J. M. Orr, Equitable Auto Co., Who Analyzed the Problem of Fleet Repair Shops versus Manufacturers' and Commercial Repair Shops. (15) W. P. MacCracken, Jr., Chairman of Washington Section, Toastmaster at Transportation Dinner. (16) W. R. Smith, President American Road Builders Association, Speaker on the Present Trend in Highway Construction. (17) Roe Fulkerson, Humorist, Who Entertained the Diners.

to report to the public the comparative excellence of commercial products, but a system has been encouraged whereby manufacturers certify, as by means of labels, that their products conform to certain specifications or standards.

**Motorcoach Body and Chassis Relations**

Body and chassis relations in a motorcoach furnished the topic for discussion at the morning session on Oct. 25. Two papers were presented; the first, by W. C. Naegel, of the Bender Body Co., discussed the relation of the body to the chassis, and the other, by George H. Scragg, of Mack Trucks, Inc., outlined the relation of the chassis to the body.

According to Mr. Naegel, the body is the most important factor from the rider's viewpoint, and the demand for more comfortable, better appearing and safer vehicles has been the compelling cause of many design changes. Standardization on the conventional city, the intercity and the so-called metropolitan types has made the life of the body relative to the chassis the predominating influence. Replacement of chassis parts or their repair by modern maintenance methods results in a practically indefinite life for the chassis. Body parts cannot be replaced as readily, and repairs have frequently impaired their original strength, with a resultant shortening of their life and increase in maintenance cost. Composite and metal bodies have overcome this obstacle to some extent. Cross-member mounting has given the best results, since it provides for freedom of movement by the chassis without arresting the twist in the side-rail or transferring it to the body.

Minimum weight per seat on the shortest possible wheelbase was mentioned in the discussion by A. H. Gossard, of the Middle West Utilities Co., who stated that a saving of over 35 per cent had resulted from using Dowmetal for seat frames. While admitting that this construction did reduce weight, Mr. Naegel pointed out that the seat frame weighed only 14 lb. as compared with 78 lb. for the complete seat and under these conditions the additional expense for Dowmetal frames is hardly warranted. In his opinion a soft cushion is no more comfortable than a harder seat and the latter is less expensive and lighter.

Following the presentation of Mr. Scragg's paper, which was abstracted at some length in the November issue of the S.A.E. JOURNAL, p. 350, ventilation and the dispersion of the exhaust were discussed. The larger engines now used were mentioned as causing exhaust-gas odors in the vehicle, and streamlining of intercity motorcoaches was suggested as a possible remedy. Carbureter adjustment and the use of catalysts to produce an exhaust that is free from smoke and poisonous effects received considerable attention from several speakers. The need of cooperation between chassis and body manufacturers also was emphasized.

**Self versus Service-Station Maintenance**

An analysis of a broad survey of fleet-servicing methods was presented by J. M. Orr, Equitable Auto Co., Pittsburgh, at the afternoon session held Oct. 29. A lively discussion ensued. The paper, Equipment and Operation of Fleet Repair-Shops versus Manufacturers' and Commercial Repair-Shops, was a report which included self-maintenance as compared with service-station maintenance for different classes of operation.

F. K. Glynn remarked in the discussion that, previous to the summarized data in the paper, actual field conditions as to what maintenance is being performed by operators and what by the dealers', manufacturers' and other types of service stations had not been properly realized. A. H. Gossard was surprised to see, he said, that 55 per cent of the work done for fleets having 200 vehicles or more is done by outside service stations. He outlined the cost-per-mile study his company made in 1930.

L. V. Newton analyzed some of Mr. Orr's data, deducing that operators send outside 54.2 per cent of the work, and service stations 35.9 per cent; hence, that few realize how much work the outside service stations send to other shops.

Chairman Pooley's question as to why the manufacturers do not cooperate better in solving these problems was answered by John White, of Mack Trucks, who explained how some service-station difficulties are overcome by his company in Baltimore. B. H. Eaton, suggested that manufacturers use as a slogan "Service Is the Keynote of Success." Henry Dakin cited the great extent of his company's territory as one reason for its inability to use complete self-maintenance, and outlined his company's methods.

Capt. S. G. Henry, U.S.A., advocated a system that will assure adequate lubrication, a critical inspection to determine faults, and a follow-up routine for adjustments and repairs, then discussed preventive maintenace. Clinton Brettell reviewed the R. H. Macy & Co. maintenance practices. M. C. Horine advocated consideration of Mr. Orr's paper as a progress report. The way to make a service station pay, he said, is not to burden each job with all that the traffic will stand, but to get more jobs.

J. W. Cottrell, of the *Commercial Car Journal*, outlined the handicaps of self-service, emphasizing that circumstances alter cases and giving pertinent examples. Adrian Hughes suggested that data be obtained on the relative performances of motor-vehicles when serviced under the several methods of maintenance.

# John N. Willys and "Senator" Ford to Speak

## *William P. MacCracken To Be Toastmaster at Annual Dinner, Jan. 14, at Hotel Pennsylvania, New York City*

THE DINNER COMMITTEE takes pleasure in announcing that John N. Willys, United States Ambassador to Poland, is to be the speaker at the Annual Dinner. This enjoyable event, which will be held at the Hotel Pennsylvania on Jan. 14, the Thursday evening of the New York Automobile Show Week, gives every indication of being an occasion sure to be long and happily remembered by all who have the good fortune to attend it. Mr. Willys, who has recently returned to this Country, possessing the same lively interest in automotive work that characterized him during the many years when he was closely connected with it, will be welcomed by many of his old friends in the industry when he addresses the Annual Dinner.

William P. MacCracken, formerly Assistant Secretary of Commerce for Aeronautics, now of the firm of MacCracken & Lee, will serve as toastmastee, to the gratification of all who are interested in the success of the Dinner.

"Senator" Ford, well-known and well-liked in the automotive industry, will add to the merriment of the occasion with the lively and penetrating shafts of his wit.

Adolph Gelpke, F. K. Glynn and Norman G. Shidle are to be commended for having provided a program that can be guaranteed to please our discriminating Annual Dinner audience.

# Annual Meeting in Detroit, Jan. 25-29

## *Sir Dennistoun Burney Will Talk on Streamlined Car—*

## *Other Sessions Replete with Interest*

THE WEEK of Jan. 25 will be full to overflowing with events of interest to Society members, because the Society's Annual Meeting will convene in Detroit, at the Book-Cadillac Hotel, on Monday, Jan. 25, and technical sessions will be held throughout the week until Friday, Jan. 29. The program that is being arranged promises to be truly representative of all interests of the Society, as the various Professional Activities have taken part in planning the sessions.

The Passenger-Car Activity is sponsoring three technical sessions, at which consideration will be given to front-wheel alignment, bearings and chassis matters. Other sessions, sponsored by the various Activities, will be devoted to problems of passenger-car bodies, transportation and maintenance, motor-coaches and motor-trucks, aircraft, Diesel engines and production.

In addition to the sessions outlined by the Professional Activities, there will be a Standards Session, a Research Session and a General Session. The last named will be sponsored by the National Meetings Committee and will be preceded by a dinner at which the Detroit Section will act as host to the National Society.

An added attraction will be an evening session for students, for which a program of outstanding merit is being prepared by Alex Taub, Chairman of the Detroit Section, and R. N. Janeway, the Detroit Section's Vice-Chairman for Student Activities. The program for this session will be of such a character as to appeal to the members attending the Annual Meeting as well as to the students in whose interests it is being arranged.

### Papers for Passenger-Car Sessions

The Front-Wheel-Alignment Session will include a paper on Front-End Engineering in Relation to the Service-Field Situation, by C. P. Grimes, of the Grimes Brake Engineering Service; one on the Geometry of the Front End, by W. R. Griswold, of the Packard Motor Car Co.; and an Analysis of the Work and Conclusions of the Front-Wheel-Alignment Research Subcommittee, by Professor J. M. Nickelsen, of the University of Michigan. The program for this session has been arranged for the Passenger-Car Activity by B. J. Lemon, a member of the Committee and Chairman of the Front-Wheel-Alignment Committee.

Bearings and their problems will be discussed at a symposium at which the subject will be considered from three viewpoints, that of the oil man being given by D. P. Barnard, 4th, of the Standard Oil Co. (Indiana); that of the bearings manufacturer by J. V. O. Palm, of the Cleveland Graphite Bronze Co.; and that of the car designer by Alex Taub, of the Chevrolet Motor Co.

### A Distinguished Foreign Speaker

Sir Dennistoun Burney, internationally known for his activities in connection with both automobiles and aircraft, has accepted the invitation, extended to him by Walter C. Keys on behalf of the Committee, to come to this Country in January and talk at the Annual Meeting on his streamlined automobile. It is understood that Sir Dennistoun will bring two cars with him for purposes of demonstration and that in his address he will emphasize the advantages to be gained from streamlining and from mounting the engine in the rear.

A very interesting paper will be given in which a new type of engine mounting will be discussed by N. F. Hadley, R. K. Lee and R. N. Janeway, all of the Chrysler Corp. This paper will consist of two parts; in the first part, Mr. Hadley will give an interpretation of the "floating-power" mounting from the production angle, whereas, in the second part, Messrs. Lee and Janeway will give the technical side of the design, discussing the development of the floating-power principle.

Another interesting feature of this session will be a report on the riding-qualities research by Dr. Fred A. Moss, of George Washington University.

Body engineers will find a session arranged for their special benefit, at which two papers will be presented. In one of these, Maxwell Halsey, of the National Bureau of Casualty and Surety Underwriters, will discuss Safety Factors in Automobile-Body Design; in the other paper, C. L. Humphrey and B. Steensen, both of the Chrysler Corp., will give some data on Noise and Heat Control in the Automobile Body.

### To Junk or Not To Junk

Only one paper is being scheduled for the Transportation and Maintenance Session, but that promises to be a most interesting one and its presentation undoubtedly will evoke much discussion. It will deal with standards for determining when to re-use and when to junk a used part. The speaker chosen to talk on this vital topic is Joseph Geschelin, of *Automotive Industries*.

The trend of size and type of power-plants and transmissions in motor-coaches and motor-trucks is the general subject selected for the Motorcoach and Motor-Truck Session. Two papers are to be given on this topic: one by Lieut.-Col. Brainerd Taylor, chief of the motor-transport branch, transportation division, Quartermaster Corps, United States Army; the other, by Hubert Walker, of the American-La France & Foamite Corp.

An evening session which will be of interest to everyone attending the Annual Meeting will be that at which Brig.-Gen. H. C. Pratt, chief of the Materiel Division, Army Air Corps, will talk on Speeding up the Army in the Air. This session will be preceded by the Society's annual business meeting.

An attractive session has been planned by the Diesel-Engine Activity. A. W. Pope, Jr., of the Waukesha Motor Co., will talk on the interrelation of Diesel fuel and engine characteristics, and the committee will issue information later about a second speaker and topic.

Further developments in the study of the vapor-lock problem being made as a part of the Cooperative Fuel-Research will be presented by Dr. O. C. Bridgeman, of the Bureau of Standards, and other investigations of the fuel-research program will be reported at the same session.

### Plans for Dinner and General Session

On the final evening of the Annual Meeting, Chairman Alex Taub and the members of the Detroit Section will act as hosts to the National Society at a dinner which will be followed by the General Session under the sponsorship of the National Meetings Committee. The Meetings Committee will be ready at a slightly later date to announce the name of the speaker for this occasion and the topic on which he will talk.

The Production Activity Committee is working on the program that is to be presented at the session sponsored by the Production Activity, and an announcement will be made about it later.

Chairman Shidle, of the Meetings Committee, states that all Annual Meeting sessions will start on time and that each session will adhere strictly to a time schedule. The following of such a time schedule, carefully laid out in advance and clearly understood by each session chairman and the speakers at each session, will ensure an equitable division of time so that no speaker can encroach on the time of another and, after the scheduled speakers have been heard, ample time will be available for discussion.

# Chronicle and Comment

**Don't Miss the Annual Dinner!** ONE *sure-fire* address, a half hour of hilarious wit, a delectable repast and lively entertainment will supply the background for the kind of sociability that our members enjoy at the Society's Annual Dinner. It is not too early to set aside the evening of Jan. 14, Thursday of Automobile Show Week, for this event. Detailed information regarding the Dinner will be found on p. 428 of this issue of THE JOURNAL.

**Annual Meeting Taking Shape** A NUMBER of new and unusually interesting items will feature the Annual Meeting program for 1932. Already the sessions are sufficiently settled to show that Jan. 25 to 29, inclusive, will be banner days of the Society. Our Activities and committees are still busy completing final arrangements. Details regarding the meeting will be found in this issue of THE JOURNAL and in meetings announcements.

**Society Membership Should Increase!** MEMBERS of the S.A.E. should make the most of every opportunity to bring the Society's advantages to the attention of their associates. Hundreds of engineers who are fully qualified for membership are still outside the fold simply because they have never known the benefits that the Society has to offer. From the standpoint of prestige alone, membership is worth many times its cost. This and many other valuable considerations have been responsible for the steady growth of our organization from a very small beginning to its present size and power.

**Transportation Experts Discuss Controversial Topics** ONE REASON for the success of the Society's Ninth National Transportation Meeting, held last month in the City of Washington, was the controversial nature of several of the important subjects that were so ably presented. For example, George Green showed concrete evidence as to why he was not favorably inclined toward Diesel engines for commercial vehicles; other speakers held other views. S. O. Dunn expressed his opinions on coordination of railroad and highway transport; A. J. Scaife and others begged leave to disagree on various points. At any rate, three days were crowded with worthwhile consideration of transportation problems and the meeting was called a huge success.

**Accelerating in Baltimore** OUR BALTIMORE Section has formed an ACCELERATING COMMITTEE for the purpose of making a fast-moving Section move faster. An excellent name, and a fine idea with great possibilities! Several energetic members are working with G. O. Pooley, Accelerator in Chief, to bring the values of S.A.E. membership to the attention of qualified automotive engineers in the Section's territory. Further evidence of acceleration in Baltimore is shown by the specific announcement of Chairman Boehm's completed plans for excellent meetings in December, January, February and March.

**Petroleum Institute Continues Support** GREAT ACCOMPLISHMENTS have issued from the Cooperative Fuel-Research work that has been promoted during the last 10 years by the National Automobile Chamber of Commerce, the American Petroleum Institute, the National Bureau of Standards and the Society. It is very gratifying to the technologists and management executives of both industries to sense the approval of the petroleum industry for what has been accomplished, concrete evidence of which is found in the recent action of the Board of Directors of the American Petroleum Institute, which appropriated an additional $4,000 for continuance of the research. The National Automobile Chamber of Commerce also continues as a financial sponsor of the project.

**Research on Extreme-Pressure Lubricants** THE Lubricants Research Subcommittee, which was approved by the Research Committee and the Council at the time of the last Summer Meeting, set forth its purpose as follows: To develop tests to evaluate the properties of extreme-pressure lubricants and to develop tests to determine the lubrication requirements of gears and bearings, with the idea of correlating the tests on the oils with the requirements of the gears and bearings.

The Committee, as organized, includes representatives of axle and transmission, truck, automobile and bearings manufacturers, oil producers and motor-vehicle operators.

At a meeting of the Executive Committee of the Subcommittee held in Chicago on Nov. 11, the members unanimously agreed that the first step in the program should be the collection and analysis of all available data on extreme-pressure lubricants obtained in laboratory tests or in service. The chairmen of the various groups have agreed to invite the members of their subcommittees, together with representatives of other interested companies, to submit any such material they may have available to Dr. H. C. Dickinson, of the Bureau of Standards.

**Standards Making Headway** AMONG MORE than 75 projects in progress before the Divisions of the Standards Committee are mountings for airplane cameras, wood propellers, carbureters and other aircraft fittings; a standard for taper roller bearings; Diesel-engine fittings and their mountings; and revised specifications for insulated wire and cable and storage batteries for various types of vehicle.

In the metallurgical field, work is in progress on further development of iron and steel specifications and physical-property charts, including aircraft steels and non-ferrous metals.

A study of motor-vehicle chassis lubrication, to simplify both fittings and lubricants, is in progress, while in the field of screw-thread products the refinement of existing standards for screw-threads, screws, bolts and nuts and a broad survey of modern requirements in practice are probably the most important projects.

# Some Problems of the Motor-Transportation Executive

Transportation Meeting Paper

By T. L. Preble[1]

SEVERAL major problems that confront the man who has charge of a fleet of automotive vehicles are analyzed by the author, who states that they deserve closer scrutiny and more intensive study. Their solution lies in evolution, which requires time, and their continued discussion by the Society is imperative. They are problems not only of the transportation executive but of the entire industry.

Centralized control of a company's equipment is discussed, its advantages are enumerated, the ideal organization and procedure are outlined, the difficulties to be anticipated are listed and a procedure for installing such a system is proposed. The author recognizes that, where the automotive activities of a gigantic company are spread over a wide territory, application of an ideal system of centralized control is very difficult.

Consideration is given to the relationships between the transportation executive and the motor-vehicle manufacturer. These are the relations of buyer and seller, yet a peculiar need of the automotive industry is that buying and selling be conducted on a high professional plane and in a spirit of tolerance born of intelligent appreciation of the other man's problem. The transportation industry demands salesmen who not only know specifications and prices but who have pleasing personalities and a superior knowledge of highway transportation and the capabilities of equipment to serve specific purposes. The author believes that the transportation executive can do much to improve the quality of salesmen.

Selection of the right unit for a specific service depends upon a clear and definite understanding between buyer and seller of all the facts of the case and implies technical ability on the part of both. Therefore a questionnaire form is proposed, with the recommendation that it be approved by the Society and its use by transportation executives and manufacturers be urged. The author also suggests the desirability of a super-committee of representatives of trade associations, sponsored by the Society, for the purpose of discussing important problems that are common to the operator and the manufacturer.

Finally, the relations between the transportation executive and his superior are discussed, the qualifications the fleet superintendent should have are enumerated and the responsibility of the higher company executive for the efficient and economical operation of the fleet is set forth. A plea is made for such executives to devote sufficient time to become acquainted with the transportation-executive's problems and to give him sufficient authority, recognition and compensation so that he can accomplish real transportation economies.

THE INTENTION is to discuss in this paper several major problems of the motor-transportation executive which deserve closer scrutiny and more intensive study than has been accorded to them. The final solution of the important problems will result from "evolution," which implies *a long time*. If evolution is to be slipped into high gear, constructive, animated and continuous discussion by the Society is imperative. The expression "motor-transportation executive," as used in this paper, refers specifically to the man in charge of fleets of automotive equipment. The problems discussed herein are his problems, but they also are problems of the entire industry.

## Centralized Automotive Control

It is needless to quote statistics to prove that automotive fleets are growing rapidly in size; this is common knowledge. In many instances, the annual motor-transport expenses of individual companies aggregate millions. With fleets of larger size inevitably come greater complexities of organization, of control and of coordination of activities.

It is recognized that certain factors of company organization, particularly in some of the gigantic companies which have resulted from mergers and whose automotive activities are spread over a wide area, render an ideal system of centralized automotive control very difficult; however, a concise exposition of the advantages of a centralized control, *wherever such control can and should be exercised,* will be useful.

## Advantages of Centralized Control

The following summary presents some of the more important advantages of centralized control and suggests a definite procedure for the realization of such control:

*Reduction of Capital Expenditure.*—By

(1) Centralized purchase contracts, based on consolidated commitments and large savings through quantity purchases

(2) Parts and equipment inventory reduction

(3) Standardization of *types* of equipment for specific duties and a consequent reduction of number of truck sizes used

(4) Standardization of *make* of equipment and consequent reduction of number of makes used

(5) Ability of central control to interchange equipment between companies and reduce idle time of equipment and miscellaneous expenditures

(6) Proper control of routing and assignment of equipment to meet requirements of various localities

(7) Possibility of pooling transportation and maintenance activities in specific territories through

[1] M.S.A.E.—Sales manager, Pierce-Arrow Division, S.P.-A. Truck Corp., Buffalo N. Y.

coordination of activities which can come only through centralized control

*Reduction of Operation Expenses.*—By

(1) Centralized purchasing
(2) Reduction of superfluous overhead
(3) Districting of equipment by make of truck to simplify maintenance and operation
(4) Standardization of service policies and shop procedure

*Facilitation of Executive Supervision.*—By

(1) More efficient handling of motor-transportation problems, which have become such a large, technical and complex factor in the operation of many large industries as to demand the same type of centralized control that is exercised over other important departments of the business, such as merchandising and production
(2) Elimination of inter-organization friction, intrigues and controversies, through codified standard practice and clearly defined authorities
(3) Educational activities to overcome antiquated and expensive practices
(4) Standardization of transportation cost-accounting, which will permit the experience of one unit or subsidiary to be cited for the benefit of other units without costly experimentation by the other units
(5) Exercise of closer scrutiny and improved judgment in replacement of worn-out or unsuitable equipment, because of broader perspective furnished by a uniform cost-accounting system and centralized executive control. This ever-present problem is one demanding keen analysis and a high degree of coordination and control if wasteful practices are to be avoided
(6) An improved spirit of cooperation among employes of a motor-vehicle department due to the existence of clearer job-standards and corresponding ability of comparing the performance records of employes

## Ideal Organization and Procedure

First, for many and obvious reasons an ideal motor-transportation set-up cannot be installed hastily; but such an ideal program should be planned for and used with such modifications as may become necessary, as a goal toward which to work. This goal should be thoroughly understood and "sold" to the organization.

Second, clear and explicit definition must be made of the responsibilities, relationships and authorities of all concerned.

Third, the responsibilities of the supervisor of motor equipment should embrace the items enumerated in the last section of this paper. Central control must prescribe and codify the rules under which motor transportation in all branches and subsidiaries should operate; that is, the rules by which the actual operating personnel must be guided. To the supervisor of motor equipment must be delegated ample authority to carry out these responsibilities. Each subsidiary unit should be notified as to its exact status and full cooperation should be requested.

## Difficulties To be Anticipated

First, it is normally to be expected that each division or subsidiary will be jealous of its right to purchase and operate its equipment as in the past. Resentment of any centralized control is natural and to be expected, temporarily.

Second, such manufacturers of motor equipment as are not producing suitable equipment to meet requirements or whose prices are excessive and who do not enjoy business with a central control will contact with the official personnel of subsidiaries and, by excellent sales effort, tend to embarrass the proper functioning of central automotive control.

## Proposed Procedure for Installation of Program

The engagement of an automotive engineer of broad experience, who is thoroughly familiar with present automotive equipment and practices and also with the highly complex technicalities of the industry in various parts of this Country, is recommended. Such a man may already exist within the organization. This engineer must be familiar with modern accounting practices.

This new executive, who would be in charge of the entire operation, must necessarily be a man who can win confidence, not only by his knowledge of motor transportation as applied to the company's particular problem, but also by reason of his ability to exercise the tact and resourcefulness which would be necessary to a speedy and successful working out of the program. He must be armed with all necessary authority and prestige. He should visit the units of the company for several months and become thoroughly acquainted with them, their personnel and their transportation problems; also, *he should sell himself to the personnel.*

When his preliminary survey is completed, it should be this engineer's duty to submit for approval a codified standard practice for centralized automotive control, as well as a proposed detailed organization chart to follow out this standard practice. This engineer supervisor will require complete support of the management at all times, as such pressure will be directed upon him both within and from without the organization as to make his important and difficult task impossible without full executive support.

## Relations with the Manufacturer

Several of the many relationships which exist or should exist between the transportation executive and the motor-vehicle manufacturer and that are susceptible to marked improvement will now be discussed.

The transportation executive is the buyer, the manufacturer is the seller, and each is bound to be actuated by the usual objects which are common to all buyers and sellers. However, there exists in the automotive industry a peculiar need that, in the best interests of both, the buying and selling process be conducted upon a higher professional plane and in that spirit of real tolerance which is born only of an intelligent appreciation of the other man's problem.

## Good Salesmanship Outlined

Altogether too often does the manufacturer's sales representative, through ignorance of his job or occasionally through deliberate misrepresentation, bring upon himself the reputation of being a "one-time salesman." Too frequently do we find the buyer who fails to state his transportation needs accurately and completely. The result inevitably is dissatisfaction and dispute, which are costly to both buyer and seller.

Consider the salesman. Frequently he is far less than profound in his knowledge of even the bare fundamentals of highway transportation. Although at present we see fewer salesmen whose selling method was indicated by shiny left elbows and baggy right knees, the industry is still afflicted with salesmen who are undertrained for their jobs. The fault lies as much with the manufacturer as with the man. As the superintendent of a large fleet said recently:

So far as I am concerned, I don't want to talk to any more salesmen. Send me an engineer or, at least, a service man. I want to talk to somebody who will really *contribute* to my knowledge of motor-transportation problems. The average salesman shows me a pretty catalog, gives me the same old line, and, when he has gone, I find that I simply lost half an hour of valuable time.

A motor-vehicle salesman may have specifications and prices at the tip of his tongue; he may have a pleasing and a forceful personality and many other fine attributes; but, if he expects to wear well with his customers, he *must* be able to enlighten them through his superior knowledge of motor-vehicles and highway transportation and through his ability to apply this knowledge to the needs of the customers to whom he is talking. Such a man—fortunately, his tribe is multiplying—has no fear of that sales malady known as "the hot door-knob." This industry demands salesmen who *know their business.*

I do not consider the foregoing remarks as irrelevant to the subject of this paper because, first, the intelligent salesman performs a necessary function in this industry and, second, I believe that the transportation executive can do much to improve the quality of salesmen. For example, he can, and frequently does, express himself by refusing to buy; but, in addition, it is highly important that he express himself on the subject most forcefully to higher executives of the manufacturer and his selling agents. It is certain that, in these high-tension times, the manufacturer listens as never before to the words of the source of his bread and butter, the customer.

On the other hand, the transportation executive can make the salesman's lot happier if he will be more specific and definite preceding the sale as to exactly what his requirements are. Fortunately, there is a growing tendency toward the publishing by prospective buyers of more explicit information.

Because men are human, overselling will never be entirely eliminated, nor will "under-buying," But, because of salesmen's encroachment upon the transportation executive's time, the salesman is surely an important factor in the transportation man's daily work. A better appreciation of these factors by both may eventually bring about a day when salesmanship shall be almost if not quite painless.

### Purchasing the Right Unit

Failure of the manufacturer to sell and of the transportation executive to buy the transport unit most scientifically adapted to predetermined requirements is admittedly of such consequence as to need no elaboration herein. To state a well-known fact is simple; to suggest an infallible remedy is probably impossible, but to recommend a constructive procedure which will be helpful is very much in order.

The installation of the most suitable unit depends upon *a clear and explicit understanding between the buyer and the seller of all the pertinent facts* and implies a technical ability on the part of both buyer and seller to interpret the facts correctly in terms of the unit. Use of the questionnaire method certainly is not a new idea, but an insistence by the buyer and the seller upon its use wherever desirable unquestionably would result in substantial transportation economies. Herewith is a suggested questionnaire, and the recommendation is made that it be adopted by the Society and that its use by transportation executives and manufacturers be urged. This questionnaire, if properly filled in, will provide essential data from which engineering calculations such as the ability factor, load distribution and suitable gear ratios can be computed with a large degree of accuracy.

QUESTIONNAIRE FOR USE BY TRANSPORTATION EXECUTIVES AND MOTOR-VEHICLE MANUFACTURERS

Customer's Name .....Address .....
Customer's Business .....Material Hauled .....
Pounds Payload to Be Hauled.....Number of Loads Per Day (Average) .....
Maximum Road-Speed .....
Required Daily Mileage per Truck....Number of Trips per Day....
Length of Working Day.....Number of Days per Week.....
Number Weeks per Year.....
TERRAIN—Level .....Maximum Grades.....Average Grades.....
Length of Longest Grade.....Road Surface.....
Percentage of Haul in City.....In Country.....
TRACTOR—Payload to Be Hauled.....
Semi-Trailer: Size.....Weight.....Capacity.....
Four-Wheel Trailer: Size....Weight....Capacity....
Number of Electric Lights Required on Trailer .....Total Candlepower.....
BODY—Type .....Capacity.....Weight.....Dimensions.....
HOIST (if used)—Make.....Model.....Weight.....
SPECIAL EQUIPMENT .....
.....
.....
*REMARKS* .....
.....
.....

### Trends in Design

One of the most important relationships which can exist between the transportation executive and the manufacturer has to do with trends in motor-vehicle design. The importance of this is self-evident. The manufacturer who can more accurately forecast design trends so that he may be in a more favorable position *to know just what to build* is fortunate indeed.

I firmly believe that considerable of the guesswork which must be undertaken under present conditions can be eliminated. Buyers and sellers should, by all means, draw closer together in matters of transportation and design research. For one thing, it is incumbent upon the manufacturer to insist that his engineers spend more *personal* time with both large-scale and small-scale motor-vehicle buyers. The inadequacy of such contacts in the past cannot be properly explained. It is true that the engineer who calls upon a great number of buyers in many different vocations will receive many conflicting and contradictory statements. He will, nevertheless, observe trends and receive many splendid suggestions from the operating men. Too often does the manufacturer's designing engineer cloister himself in his own office and depend upon his examination of competitors' specifications and his conversations with his own personnel, instead of personally exposing himself to the customer, the man who ultimately pays his salary.

The recommendations already made by certain trade associations, such as those of the American Petroleum Institute in regard to *CA*, or cab-to-axle, dimensions, are of great importance to the manufacturer. If, in addition to the engineer's personal contact with the customer—referring specifically to the transportation executive, to whom this paper is dedicated and who often is a member of a trade association—this executive would use his influence toward obtaining a more specific statement of their design problems by some of these associations, a great benefit would result. In addition, I would suggest the desirability of a super-committee, sponsored by the Society and composed of delegates from all the major trade associations, for the purpose of discussing problems that are important to the owners and manufacturers alike. Through this clearing house for ideas there would emerge a clearer composite picture that would benefit the manufacturer and guide him in his design and manufacturing problems. Guesswork would thus be largely eliminated and customers' requirements would be more scientifically met.

I believe that the foregoing recommended procedures eventually would more thoroughly impress the manufacturer with the necessity for instituting basic systems of design which would permit far more flexibility in respect to supplying customers' needs and also mini-

mize his own internal problems of inventory and manufacture.

The manufacturer has, for years, been selling what he terms a "line" composed of "models." The word "models" implies a certain fixity or restriction of design; a "take-it-or-leave-it" idea. If the broad conception of what constitutes a "line" of motor-vehicles were enlarged to the extent of eliminating models, as such, and substituting therefor a system of standard units which, through the basic-design idea, could be assembled into any combination within reason to suit the customers' requirements, the result would be two-fold. The buyer would benefit by designs which would more nearly meet the exacting requirement of his particular operation, and the manufacturer would benefit through increased economies of tooling-up expense, of inventories and of the manufacturing process.

Transportation executives, by more definitely crystallizing statements of their operating requirements, can present such a united front to the manufacturers as to permit the latter to produce designs which will be simpler, more flexible and possessed of inherent economies which will benefit the entire industry.

### The Transportation Executive and His "Boss"

I take it that everyone has a "boss" and that much time is spent in high-pressure thought as to how to get along with the boss. Many of us are blessed with immediate superiors who are alert to our problems and who are cooperative and constructive in their attitudes toward us. To a few, no doubt " 'boss' is a horrid word," to paraphrase the slogan of a cigar manufacturer. In any event, he is with us and we must make the best of it.

A rather general feeling exists, which no doubt is at least partly justified, that in many cases the higher company executive, either through ignorance or lack of time, is deficient in such genuine appreciation of the problems of his transportation executive as to give to him the time and attention, as well as the responsibility and authority, which are justified by the important and intricate nature of his job. I purpose, therefore, to discuss rather intimately the personal status of the transportation executive in his company, and such discussion cannot fail to mention the higher company executive, his boss.

### Transportation-Executive Characteristics and Duties

Like other human beings, a transportation executive can be classified as good, bad or indifferent. He is sometimes addicted to self-pity. Often he possesses the well-known inferiority complex. Still oftener he lacks the self-energizing ability which is so important if he is to solve the many difficulties under which he labors. The old carpet slippers look pretty good to him at the end of the day. He lacks the initiative and the personality, as well as the broad perspective of his job, which he needs to "sell" its importance and his importance to his chief executive. Surely this type of transportation executive is largely responsible for the lack of recognition about which he complains. F. C. Horner states well that

> If one is familiar with the game, he has very little difficulty in obtaining the services of good operation and maintenance talent; but, when it comes to finding a man of ability with a wealth of experience in applying this new transportation tool, the motor-vehicle, to the haulage problems of today, whether it be the movement of freight or of passengers, then we have another story.

On the other hand, we find in the great majority of motor-transportation executives men of sincere purpose, of long experience in the business, desiring only that recognition of the importance of their position should come from a realization of the operating results which they achieve.

The duties of a superintendent of transportation are summarized by F. K. Glynn as follows:

(1) Build up an efficient operating organization.
(2) Determine the most efficient type, make and size of chassis, body, accessories and auxiliary equipment for the job.
(3) Determine the economic time for replacement.
(4) Arrange for the purchase of all automotive equipment, maintain an adequate stock of parts and supplies and arrange for the disposal of replaced equipment.
(5) Determine the practices to be followed in the daily maintenance and in the repair of the vehicles.
(6) Locate, lay out and equip garages and shops.
(7) Collect, compile and study operating data to effect improvements and economies.
(8) Measure operating results.
(9) Study the use of the vehicles in the field with a view toward increased productivity and the elimination of lost time.
(10) Determine the qualifications of the drivers and train them in the safe operation and efficient care of the vehicles.
(11) Review proposed motor-vehicle laws.
(12) Handle registrations and licenses.

To the foregoing L. V. Newton adds the following summary of personal characteristics which the transportation executive should inherently possess. He should

(1) Be absolutely honest and loyal to his employer
(2) Have business common-sense
(3) Have a good education, preferably engineering training
(4) Preferably have a good working knowledge of motor-vehicle repair-work gained through actual experience in automotive repair-shops
(5) Be of broad caliber, quick to gain a working knowledge of the problems of his company
(6) Have the training and ability to analyze motor-vehicle cost reports correctly
(7) Have a good personality that is capable of winning the confidence of those with whom he comes into contact
(8) Be an analyst, basing his actions upon facts rather than suppositions or guesswork

If these "personal specifications" represent an ideal man, they at least suggest standards for the transportation executive to work toward.

As stated by James C. Bennett,

> Today's fleets of motor-vehicles demand the interest and care of thoroughly competent executives. It is not sufficient to elevate a skillful driver, or a thoroughly trained mechanic, or even an engineer who is well qualified, primarily, as a designer, to this position of executive responsibility.

The transportation executive of the type analyzed herein is not common even today, but the number of such men is increasing. His job is obviously of tremendous importance. If it is done well it deserves recognition which has not been given to it in many cases. If such recognition for proved ability is not eventually forthcoming, the result inevitably will be that of lowering the business and the technical and executive quality of transportation superintendents, with a consequent loss of no mean proportions to the owner.

### The Transportation Engineer's Boss

Quoting Mr. Newton again:

> There are today a large number of business houses employing motor-vehicles, operating them in a haphazard manner and without the supervision of a

(*Concluded on p.* 441)

# Summary of 1931 Motor-Truck Legislation

Transportation Meeting Paper

By Pierre Schon[1]

A MOST CRUCIAL legislative situation affecting the motor-truck industry obtained during the 1931 legislative sessions in 44 States of the Union. Their enactments brought no improvement in uniformity of permissible sizes and weights of motor-trucks, according to the author. Coordinated efforts on the part of manufacturers and operators, sponsored by the National Automobile Chamber of Commerce, resulted in defeating adverse legislation in the majority of States.

The author gives illustrations of how the very nature of the new laws enacted in several of the agricultural States shows how far opposing interests will go to cripple highway transportation.

Two "Codes" now exist which include recommendations to secure greater uniformity on sizes and weights; (*a*) the National Conference on Street and Highway Safety Code, known as the Model Act or the National Code, and (*b*) recommendations made by the Motor Vehicle Conference Committee and the National Automobile Chamber of Commerce. These two Codes differ greatly insofar as uniformity of regulations is concerned. Both make recommendations which are not in keeping with the industry's progress as regards design and operating methods.

Numerous statistical data in the form of tables and two charts are presented and commented upon. In conclusion, following a summary of the situation, the author enumerates four suggestions which, in his opinion, should be considered in setting up a standard on maximum limitations of sizes and weights of motor-vehicles.

THE MOTOR-TRUCK industry experienced a more crucial legislative situation during the 1931 legislative sessions than ever before and their enactments brought no improvement in uniformity of permissible sizes and weights. Selfish interests, opposed to the development and expansion of highway transportation, were extremely active in formulating and enacting State laws intended to cripple and handicap the operation of motor-trucks and motorbuses. These attacks on highway transportation resulted in reducing the size of motor-vehicles, reducing their weight, higher license fees for trucks and buses, and more stringent regulation of public and contract carriers.

Although attempts were made to bring about more drastic regulations in practically all of the 44 legislatures in session during 1931, coordinated efforts on the part of manufacturers and operators, sponsored by the National Automobile Chamber of Commerce, resulted in defeating proposals for such adverse legislation in the majority of States. As a result of the attacks by those interests opposed to highway transportation, well-organized State associations of bus and truck owners were formed and, in future legislative sessions, stronger opposition to unfavorable truck and bus laws will be offered.

The very nature of the new laws enacted in several of the agricultural States serves as an example of the extent to which the opposing interests will go to cripple highway transportation. In Texas, for instance, a new law will rule motor equipment worth millions of dollars off the highways. It is estimated that, in the city of Dallas alone, 400 motor-trucks will be forced to discontinue operation when these new regulations become effective. In the Houston district, it is estimated that equipment worth one and one-half million dollars will be obsoleted by the new Texas law. House Bills Nos. 335, 336 and 628, as enacted by the Texas Legislature, are typical examples of State laws written, not by highway engineers for the conservation of pavements, nor by automotive engineers interested in designing vehicles of practical sizes and weights, nor by operators and shippers interested in economical transportation; but largely formulated by hostile propagandists with the intention of driving local freight back to the rails. Similar campaigns were carried on with tremendous force in Iowa, Nebraska, Wisconsin, Illinois, Indiana, Alabama and Georgia. In some States, as many as 40 bills were presented, all affecting in one way or another the future of truck, trailer and bus transportation.

While the recent efforts to restrict and hamper highway transportation through unfavorable State laws was largely instigated by railroad interests, it should not be inferred that all railroads are proponents of restrictive highway legislation. The more progressive railroad executives realize fully that the final solution for the present problems in transportation lies in the proper coordination of rail and highway transport. For example, the New York, New Haven & Hartford Railroad Co. has achieved remarkable results in properly coordinating truck and bus transportation with its railway service. The Pennsylvania Railroad Co. has gone on record with the statement that: "Under no circumstances is endorsement given to regulations of any kind intended to force back to the rails traffic which could be more effectively moved on the highways." Similarly, many other railroads have recognized the important position of the truck and bus in the picture of transportation, and the more progressive railroads are solving their problems by intelligent coordination of rail and highway facilities.

Unfortunately, in the 1931 legislative battles, no attempts were made by neighboring States to attain uniformity of laws permitting the development of inter-State transportation. Recommendations by the National Conference on Street and Highway Safety were disregarded except in West Virginia, where the formula $L + 40$ on weights was applied unchanged, with roads and highways classified according to carrying capacity of bridges and pavements as recommended in the Model Act. The "$L + 40$" formula for establishing gross vehicle-weights, as recommended by the National Conference, was adopted by several other States in various modified and altered forms, whereby the purpose of the formula, uniformity of State regulations, was defeated.

Two codes are now in existence, including recommendations to secure greater uniformity of State legal regulations on sizes and weights; (*a*) the National Conference on Street and Highway Safety Code, known as the Model Act or the National Code, and (*b*) recommendations made by the Motor Vehicle Conference

[1] M.S.A.E.—Sales engineer, General Motors Truck Co., Pontiac, Mich.

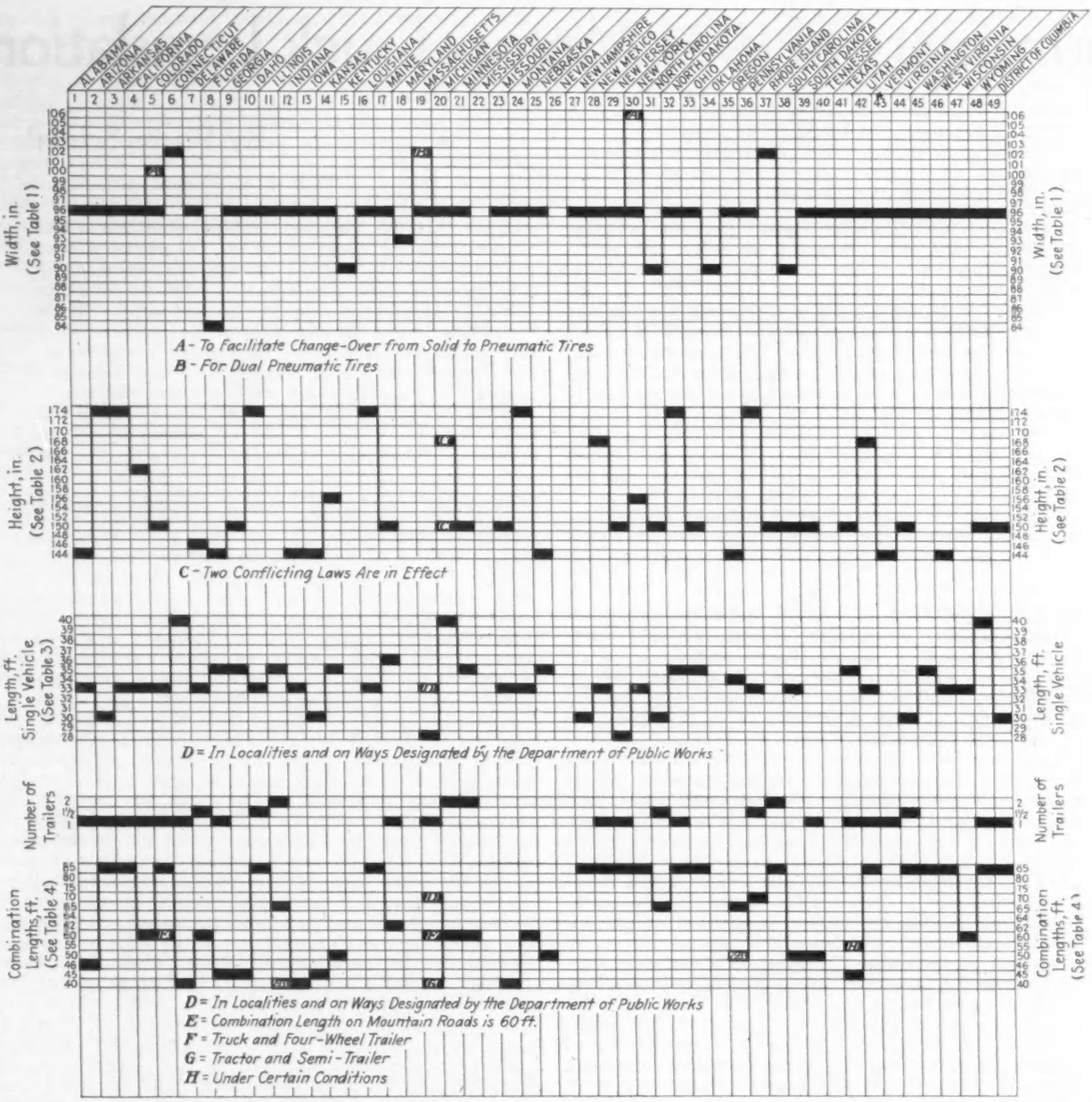



FIG. 1—CHART SHOWING LEGAL MOTOR-VEHICLE REGULATIONS ON WIDTH, HEIGHT, LENGTH OF SINGLE VEHICLES, NUMBER OF TRAILERS AND COMBINATION LENGTHS IN THE UNITED STATES

Committee and the National Automobile Chamber of Commerce. These two codes differ greatly insofar as uniformity of regulations is concerned. Both contain recommendations which are not in keeping with the progress of the industry as regards design and operating methods.

Prior to the convening of the 1931 Legislatures, the Motor Vehicle Conference Committee decided to establish a moratorium on recommendations for sizes and weights of vehicles and to retain the old code as set up several years ago. The Committee stated that the development of the multiple-axle unit and the adoption of pneumatic-tire equipment have made necessary additional tests of motor-vehicles to determine the effect of impact delivered upon the road structure.

In view of the present chaotic condition of highway legislation, it seems to be high time that the Society take the matter in hand most energetically and, through a committee appointed for the purpose, determine definitely the practical design and operating limitations on sizes and weights for recommendation to the legislative bodies of the various States. Even if action on the part of the Society is confined to an endorsement of the Model Act formulated by the National Conference on Street and Highway Safety, it would be a step in the right direction and helpful in clarifying the present maze of State laws. Possibly some modifications of the Model Act are advisable, and recommendations from the Society would crystallize requirements of the industry from the viewpoints of both the designers and the operators. The need for such action is clearly emphasized in Figs. 1 and 2 and accompanying Tables 1 to 8, compiled from the most recent information available.

*Width.*—Fig. 1 and Table 1 show that, in Colorado,

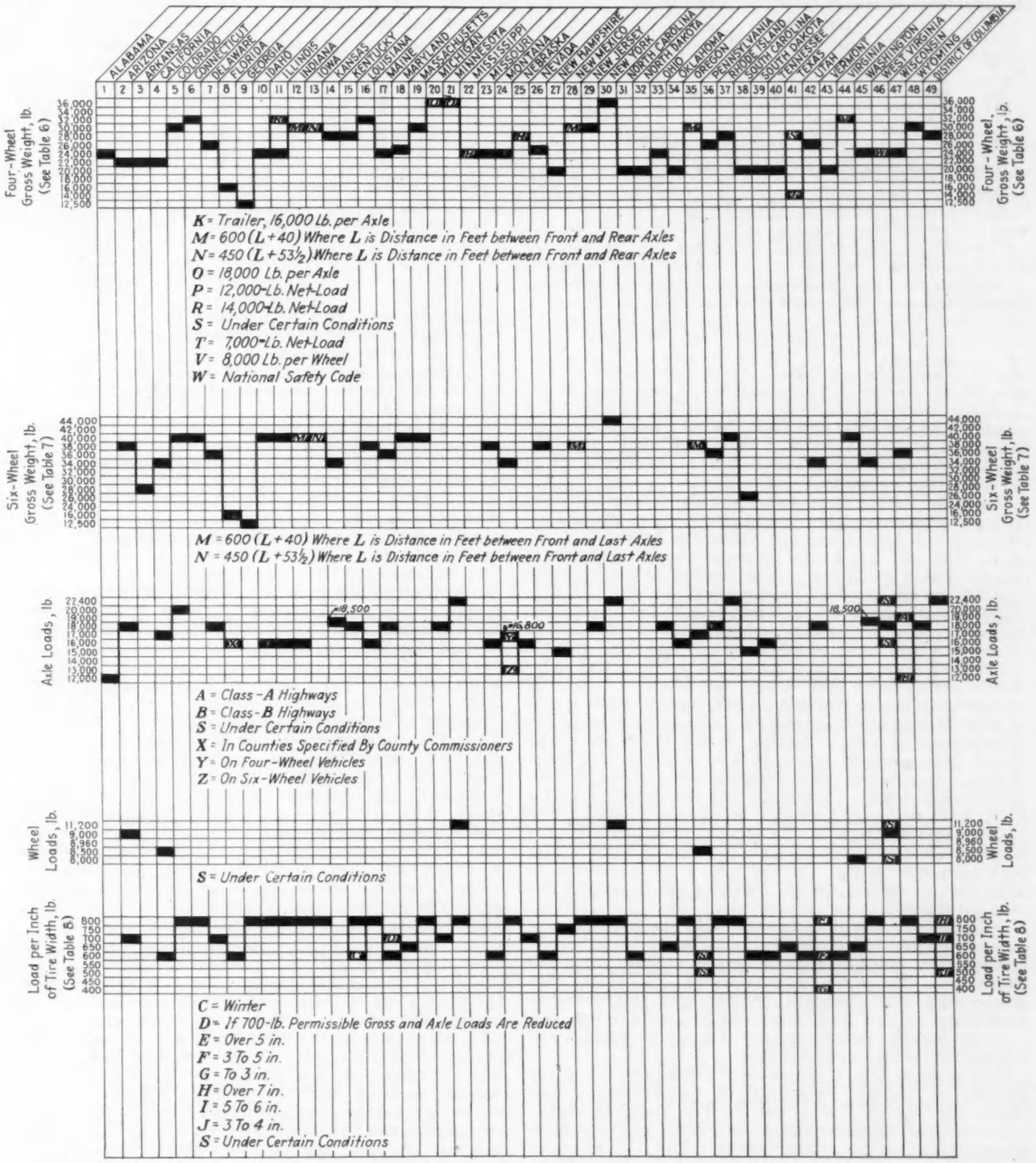

ALABAMA
ARIZONA
ARKANSAS
CALIFORNIA
COLORADO
CONNECTICUT
DELAWARE
FLORIDA
GEORGIA
IDAHO
ILLINOIS
INDIANA
IOWA
KANSAS
KENTUCKY
LOUISIANA
MAINE
MARYLAND
MASSACHUSETTS
MICHIGAN
MINNESOTA
MISSISSIPPI
MISSOURI
MONTANA
NEBRASKA
NEVADA
NEW HAMPSHIRE
NEW MEXICO
NEW JERSEY
NEW YORK
NORTH CAROLINA
NORTH DAKOTA
OHIO
OKLAHOMA
OREGON
PENNSYLVANIA
RHODE ISLAND
SOUTH CAROLINA
SOUTH DAKOTA
TENNESSEE
TEXAS
UTAH
VERMONT
VIRGINIA
WASHINGTON
WEST VIRGINIA
WISCONSIN
WYOMING
DISTRICT OF COLUMBIA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
Four-Wheel Gross Weight, lb. (See Table 6)
36,000 34,000 32,000 30,000 28,000 26,000 24,000 22,000 20,000 18,000 16,000 14,000 12,500
K = Trailer, 16,000 Lb. per Axle
M = 600 (L + 40) Where L is Distance in Feet between Front and Rear Axles
N = 450 (L + 53½) Where L is Distance in Feet between Front and Rear Axles
O = 18,000 Lb. per Axle
P = 12,000-Lb. Net-Load
R = 14,000-Lb. Net-Load
S = Under Certain Conditions
T = 7,000-Lb. Net-Load
V = 8,000 Lb. per Wheel
W = National Safety Code
Six-Wheel Gross Weight, lb. (See Table 7)
44,000 42,000 40,000 38,000 36,000 34,000 32,000 30,000 28,000 26,000 24,000 16,000 12,500
M = 600 (L + 40) Where L is Distance in Feet between Front and Last Axles
N = 450 (L + 53½) Where L is Distance in Feet between Front and Last Axles
Axle Loads, lb.
22,400 20,000 19,000 18,000 17,000 16,000 15,000 14,000 13,000 12,000
18,500
16,800
A = Class-A Highways
B = Class-B Highways
S = Under Certain Conditions
X = In Counties Specified By County Commissioners
Y = On Four-Wheel Vehicles
Z = On Six-Wheel Vehicles
Wheel Loads, lb.
11,200 9,000 8,960 8,500 8,000
S = Under Certain Conditions
Load per Inch of Tire Width, lb. (See Table 8)
800 750 700 650 600 550 500 450 400
C = Winter
D = If 700-lb. Permissible Gross and Axle Loads Are Reduced
E = Over 5 in.
F = 3 To 5 in.
G = To 3 in.
H = Over 7 in.
I = 5 To 6 in.
J = 3 To 4 in.
S = Under Certain Conditions

FIG. 2—CHART SHOWING LEGAL MOTOR-VEHICLE REGULATIONS ON GROSS WEIGHT FOR FOUR-WHEEL AND SIX-WHEEL VEHICLES, AXLE LOADS, WHEEL LOADS AND LOAD PER INCH OF TIRE WIDTH IN THE UNITED STATES

100-in. width is permitted on vehicles manufactured for solid tires but which are changed over to pneumatic tires. New York State encourages change-over from solids to pneumatics by allowing a width of 106 in. for vehicles registered prior to Jan. 1, 1933.

The most practical solution of the problem is found in the new Massachusetts law which limits the width of a vehicle to 96 in. but allows 102 in. from outside to outside of dual pneumatic tires. This means that, where dual tires are used, the outside tire projects 3 in. beyond the width of the body. This extra 3 in. on each side does not endanger safety on the highway; it permits change-over from solids to a practical size of dual pneumatics, and it solves clearance-limitation problems

TABLE 1—SUMMARY OF WIDTH REGULATIONS (SEE FIG. 1)

| Width Limits, In. | States | In Effect In, No. of States |
|---|---|---|
| None | Mississippi and Nevada | 2 |
| 84 | Florida | 1 |
| 90 | Kentucky, North Carolina, Oklahoma, South Carolina | 4 |
| 93 | Maryland | 1 |
| 96 | ..... | 39[a] |
| 100 | Colorado | 1 |
| 102 | Connecticut, Rhode Island, Massachusetts | 3 |
| 106 | New York | 1 |
| 96 | Recommended by the Motor Vehicle Conference Committee and the N.A.C.C. | |
| 96 | Recommended by the National Conference on Street and Highway Safety | |

[a] Including the District of Columbia and three States that allow greater width under some conditions.

TABLE 2—SUMMARY OF HEIGHT REGULATIONS (SEE FIG. 1)

| Height Limits In. | Height Limits Ft. | Height Limits In. | In Effect In, No. of States |
|---|---|---|---|
| None | .. | .. | 12 |
| 144 | 12 | 0 | 8 |
| 146 | 12 | 2 | 1 |
| 150 | 12 | 6 | 16 |
| 156 | 13 | 0 | 2 |
| 162 | 13 | 6 | 1 |
| 168 | 14 | 0 | 3 |
| 174 | 14 | 6 | 7 |
| 174 | Recommended by the Motor Vehicle Conference Committee and the N.A.C.C. | | |
| 144 | Recommended by the National Conference on Street and Highway Safety. | | |

TABLE 3—SUMMARY OF MAXIMUM-LENGTH REGULATIONS FOR SINGLE VEHICLES (SEE FIG. 1)

| Limits, Ft. | In Effect In, No. of States |
|---|---|
| None | 9 |
| 28 | 2 |
| 30 | 6 |
| 33 | 18 |
| 34 | 1 |
| 35 | 10 |
| 36 | 1 |
| 40 | 3 |
| 33 | Recommended by the Motor Vehicle Conference Committee and the N.A.C.C. |
| 33 | Recommended by the National Conference on Street and Highway Safety. |

for the designing engineers. With only 12 per cent of the States having width limitation of less than 96 in., and our highway engineers unanimously in favor of eliminating the solid tire from the highway, a National Standard of 96 in. and 6 in. more for dual pneumatic tires in metropolitan and industrial areas should not be so difficult to establish.

*Height.*—Referring to Fig. 1 and Table 2, in Michigan there are two conflicting height laws; one specifies a 14-ft. (168-in.) height and one limits the height to 12 ft. 6 in. (150 in.). It should be noted that 33 per cent of all the States, or 43 per cent of the States where height regulations are in effect, have a limitation of 12 ft. 6 in. (150 in.) which allows sufficient height for commercial vehicles except for unusual commodities or double-deck buses, and they could be taken care of by special permit.

*Single-Vehicle Length.*—As shown in Fig. 1 and Table 3 New Jersey has a 28-ft.-length law in effect and, while Massachusetts also specifies a 28-ft. limit, a 33-ft. length is permitted in localities and on roads designated by the Department of Public Works. While the 33-ft. single length is in preponderance, it is noteworthy that eight States have adopted a 35-ft.-length limit for single vehicles during 1931. Minnesota and Washington had a 35-ft. limit previously, and the eight States which found it advisable to increase the length limit to 35 ft. are Florida, Georgia, Illinois, Kansas, New Mexico, Texas, Nebraska and North Dakota. Is a 33-ft. limitation adequate, or is the trend toward a 35-ft. length for single vehicles?

Another problem is connected with the limitation of vehicle length. In some States, a tractor-semi-trailer combination is classed as a single vehicle; in other States it is considered as two vehicles. The status of a semi-trailer is not clearly defined, and this leads to conflicting rulings and interpretations of the law, not only in length limitations but also in licensing and registering vehicles of this type.

Referring to Fig. 1, the graphic representation of the number of trailers permitted in the various States shows the figures 1, 1½ and 2. The 1 means that a motor-vehicle can draw one other trailer; either a four-wheel, six-wheel or a semi-trailer. The 1½ indicates that a tractor-semi-trailer may draw one other vehicle. The 2 indicates that two other vehicles, either one semi-trailer and one other trailer, or two single trailers, can be hauled behind the powered unit.

In 22 States, no restrictions are imposed on the number of trailers which can be hauled, but the maximum-length restrictions on a combination of vehicles automatically restrict the number of trailers in many cases. Of the 27 States which have restrictions on trailers, 18 permit only one trailer, 5 permit one other vehicle to be hauled behind a tractor semi-trailer and 4 permit two trailers behind a motor-vehicle unit.

Looking at the combination length of vehicles permitted by the various States, we find a very wide variation, as shown in Fig. 1 and Table 4. It is of interest to note that in Colorado 85 ft. is permitted, but on the narrow mountain roads the limit is reduced to 60 ft. Illinois, in 1931, reduced the permissible combination length from 65 to 40 ft., to become effective Jan. 1, 1933. In Massachusetts, in localities and roads designated by the Department of Public Works, two single vehicles each 33 ft. long, plus drawbar length, making a total of 70 ft., is legal. The same applies to two vehicles each 28 ft. long, resulting in a total of 60 ft. for a truck and a trailer. The 40-ft. limit applies to a tractor and a semi-trailer. Oregon, in 1931, reduced the combined length from 65 to 50 ft. effective in 1933.

Regardless of the fact that 37 per cent of all States, or 43 per cent of those States having regulations in effect, allow 85 ft., a comparison with that portion of Fig. 1 which shows the number of trailers allowed reveals the fact that the 85-ft. length-limit really does not mean very much, as only four States permit two trailers behind a motor-truck. New Jersey is a good example, with a length allowance of 85 ft., yet only one trailer is permitted with a single permissible vehicle length of 28 ft. Two vehicles coupled together with a 4-ft. drawbar measure approximately 60 ft. A semi-trailer in New Jersey is classified as a single vehicle; therefore, no other trailer can be attached back of a semi-trailer. The 85-ft. combination-length, as allowed in New Jersey, does not mean anything, and a 60 or 65-ft. legal length-limit would be adequate.

### Legislative Juggling Detrimental

Adverse legislation during 1931 was brought about, in some States where no regulations were in effect controlling the number of trailers, by a few operators who took advantage of the 85-ft. length and coupled three trailers behind a truck. In one case, two 35-ft. trailers were coupled behind a tractor to haul new cars over narrow winding highways. Such isolated cases of abuse are partly responsible for some of the drastic reductions in the combination vehicle lengths as enacted in 1931. A good example which shows what operators have to face because of this constant juggling of legal limitations on sizes of vehicles is evidenced in Table 5 by some of the reductions in combination lengths enacted by the 1931 legislatures.

Uniformity of regulations was evidently of no importance in the nine States referred to in Table 5, as they adopted six different dimensions, ranging from 40 to 70 ft. Other States not having any regulations prior to 1931 have in some cases passed more stringent regulations. For example, in Indiana, a new law goes into effect on Jan. 1, 1932, limiting the combination length to 40 ft. What is the answer? If a 65-ft. limit

TABLE 4—SUMMARY OF LENGTH REGULATIONS FOR COMBINATIONS (SEE FIG. 1)

| Length Limit, Ft. | In Effect In, No. of States | Length Limit, Ft. | In Effect In, No. of States |
|---|---|---|---|
| None | 7 | 60 | 8 |
| 40 | 4 | 62 | 1 |
| 45 | 4 | 65 | 1 |
| 46 | 1 | 70 | 1 |
| 50 | 6 | 85 | 18 |
| 55 | 1 | | |

85 Recommended by the Motor Vehicle Conference Committee and the N.A.C.C.

85 Recommended by the National Conference on Street and Highway Safety.

TABLE 5—REDUCTIONS IN COMBINATION LENGTHS ENACTED BY THE 1931 LEGISLATURES

| Year | Alabama Ft. | Georgia Ft. | Illinois Ft. | Kansas Ft. | Minnesota Ft. | Missouri Ft. | North Dakota Ft. | Pennsylvania Ft. | Texas Ft. |
|---|---|---|---|---|---|---|---|---|---|
| 1930 | 85 | 85 | 65 | 60 | 75 | 60 | 85 | 85 | 65 |
| 1931 | 46 | 45 | 40 (1933) | 50 | 60 | 40 | 70 | 70 | 45 |

is sufficient for all practical purposes, except special-permit loads such as poles, timbers and structural-steel girders, why retain a recommendation of 85 ft. in the two codes and leave our State legislators without a practical recommendation to use as a guide in writing new laws?

*Weight.*—As shown in Fig. 1 and Tables 6 and 7, five States have adopted the $L + 40$ formula for controlling gross weights as set up in the National Code; but in only one State, West Virginia, was the formula adopted as set up in the Code. In the other four States, the formula was either mutilated or partly adopted only, thereby defeating its purpose, namely, uniformity of regulations.

## Gross-Weight Laws Discussed

The variations in gross-weight laws present intricate problems for manufacturers and operators. Gross vehicle-weights in some States are subject to variations from the figures given in Fig. 2 and Tables 6 and 7 due to other limitations such as axle or wheel weights. Then, again, factors of load distribution and design must be observed. For instance, New York allows 36,000 lb. gross on a four-wheel vehicle with a rear-axle limitation of 22,400 lb. In the case of a truck, this gross, with vehicle and axle weights up to maximum limits, would result in a load on the front axle of 13,600 lb. This same gross weight of 36,000 lb. on a four-wheel trailer, with two axles of equal carrying capacity, will give a gross weight of 18,000 lb. per axle.

In Michigan and Minnesota, the maximum weight per axle is limited to 18,000 lb. with no gross vehicle-weight limitation, resulting in a gross weight of 36,000 lb. for a four-wheel trailer. A conventional type of truck chassis, with dual pneumatic tires on the rear wheels, and single tires of the same size on the front wheels, would have a theoretical gross-weight limit of 27,000 lb., provided that one-third front and two-thirds rear load-distribution can be obtained. Tire capacities and design limitations are very important in the proper interpretation of State laws of gross vehicle-weights.

TABLE 6—SUMMARY OF GROSS-WEIGHT RESTRICTIONS FOR FOUR-WHEEL VEHICLES (SEE FIG. 2)

| Gross-Weight Limit, Lb. | In Effect In, No. of States |
|---|---|
| 12,500 | 1 |
| 14,000 | 1 |
| 16,000 | 1 |
| 20,000 | 8 |
| 22,000 | 3 |
| 24,000 | 9 |
| 25,000 | 3 |
| 26,000 | 3 |
| 28,000 | 6 |
| 30,000 | 3 |
| 32,000 | 4 |
| 36,000 | 3 |
| 6-Ton Payload | 1 |

28,000 Recommended by the Motor-Vehicle Conference Committee and the N.A.C.C.

($L$+40) Recommended by the National Conference on Street and Highway Safety.

Connecticut allows 32,000 lb., with no limits on axle weights. Louisiana also has a 32,000-lb. gross-weight limit on Class *A* highways, but limits maximum axle gross-weight to 16,000 lb. Virginia has a 32,000-lb. gross-weight limit, with a maximum wheel weight of 8000 lb.; and so the scale of gross vehicle-weights ranges down to 12,500 lb. gross, according to the new law enacted in Georgia in 1931. Of the 49 States, including the District of Columbia, we have 17 different weight regulations for four-wheel vehicles, subject to a variety of interpretations such as axle weights, wheel weights, load per inch of tire, weights with pneumatic tires, weights with solid tires, spacing of axles, differences in weight according to classification of highways and seasonal restrictions. But of all these complications the most serious by far is the uncertainty from the operators' standpoint as to what the next session of the State Legislature may do to the weight law. Will the new vehicle purchased this year be outlawed next year? Texas and Georgia laws are deplorable examples of legislative activities during 1931.

According to Fig. 2 and Table 7, careful checking of State laws is needed to arrive at proper interpretations of weights for six-wheel vehicles in those States where no definite limits have been set by law. In some cases, axle or wheel weights can be computed to arrive at gross weights for a six-wheel vehicle. In other States, axle spacings are so construed that the permissible gross weight on two axles is actually less than for one axle, as exemplified in the Michigan law.

## Six-Wheel Trucks and Trailers

Eighteen States do not specifically designate the permissible gross weight on six-wheel vehicles and, in most cases, the maximum as set for a four-wheel vehicle also applies to the six wheeler. New York permits 44,000 lb., and a 40,000-lb. limit has been established in Colorado, Idaho, Connecticut, Illinois, Maryland, Massachusetts, Rhode Island and Virginia. The States of Indiana, Iowa, New Mexico, Oregon and West Virginia use the same $L + 40$ formula that is applied to four-wheel vehicles. Arizona, Louisiana, Missouri and Nevada have a 38,000-lb. limit. Delaware, Maine, Pennsylvania and Wyoming limit to 36,000 lb. A limit of 34,000 lb. is in effect in California, Kansas, Montana, Utah and Washington. Arkansas limits to 28,000 lb., North Carolina to 25,000 lb. and Florida permits 16,000 lb., the same gross that is allowed for four-wheel vehicles. Georgia also has established the same gross-weight limits for six-wheel as for four-wheel vehicles, 12,500 lb. Eight States have adopted the 40,000-lb. limit; four States have 38,000-lb., four have 36,000-lb. and five have 34,000-lb. limits. Five States use the $L + 40$ formula as set up in the Model Act. The N. A. C. C. recommends 28,000 lb. gross for a

TABLE 7—SUMMARY OF MAXIMUM-GROSS-WEIGHT RESTRICTIONS FOR SIX-WHEEL VEHICLES (SEE FIG. 2)

| Gross-Weight Limit, Lb. | In Effect In, No. of States |
|---|---|
| None | 18 |
| 44,000 | 1 |
| 40,000 | 8 |
| 38,000 | 4 |
| 36,000 | 4 |
| 34,000 | 5 |
| 28,000 | 1 |
| 25,000 | 1 |

No recommendations made by the Motor Vehicle Conference Committee and the N.A.C.C. 5

($L$+40) Recommended by the National Conference on Street and Highway Safety.

TABLE 8—BALLOON-TIRE CAPACITY PER INCH OF NOMINAL WIDTH

| Tire Size, In. | Capacity, Lb. | Capacity Per Inch, Lb. | Tire Size, In. | Capacity, Lb. | Capacity Per Inch, Lb. |
|---|---|---|---|---|---|
| 8.25-20 | 2,550 | 309 | 10.50-20 | 4,700 | 448 |
| 9.00-20 | 3,250 | 361 | 10.50-24 | 5,200 | 495 |
| 9.00-22 | 3,500 | 389 | 12.75-20 | 7,200 | 565 |
| 9.00-24 | 3,650 | 405 | 12.75-24 | 8,000 | 627 |
| 9.75-20 | 3,900 | 400 | 13.50-20 | 8,200 | 607 |
| 9.75-22 | 4,200 | 430 | 13.50-24 | 9,100 | 675 |
| 9.75-24 | 4,400 | 451 | | | |

four-wheel vehicle and leaves the door wide open for a variety of regulations on six-wheel vehicles by recommending that a single vehicular unit having more than four wheels should be granted additional weight irrespective of axle spacing.

In the National Code, the gross vehicle-weight has been eliminated. Axle weights only are recommended, based on the spacing of axles and the $L + 40$ formula for controlling the gross weight of vehicle combinations primarily intended for the protection of bridges against excessive concentration of weight.

### Permissible Axle-Loads

Fig. 2 also shows permissible maximum axle-loads. The predominating axle-loads are 18,000 lb. in 12 States and 16,000 lb. in 11 States. In five States 22,400 lb., in two States 18,500 lb. and in two States 17,000 lb. are the limits. In Florida, a 16,000-lb. weight is allowable by special permit from the county commissioners. In Montana, axle weights of 16,800 lb. are permitted on four-wheel vehicles and 13,000 lb. on six-wheel vehicles. In West Viriginia, 18,000 lb. is a base figure; but 22,400 lb. is permitted under certain conditions and, in agricultural areas, the axle load is limited to 16,000 lb. In Wisconsin, 19,000 lb. is permitted on Class-*A* roads and only 12,000 lb. on Class-*B* roads. While in most cases these maximum weights apply to pneumatic as well as solid tires, there is a tendency to reduce the permissible axle-weights where solid tires are used. Such reductions were applied this year in the States of Connecticut, Delaware, Indiana, Kansas, which prohibited solid tires; Maine, Massachusetts, Minnesota, New York, Oregon, Utah, West Virginia and Wisconsin.

### Permissible Wheel and Tire Loads

Only seven States have established permissible wheel-loads; Arizona, 9000 lb.; California, 8500 lb.; Minnesota and New York, 11,200 lb.; Oregon, 8500 lb.; Virginia, 8000 lb.; and West Virginia, 9000 lb. In West Virginia, however, under certain conditions, 11,200 lb. is permitted for metropolitan areas, while for industrial areas 9000 lb. is legal and in agricultural areas the wheel load is reduced to 8000 lb.

In connection with the load per inch of tire width, six States have no restrictions. The limit of 800 lb. per in. of width predominates, 20 States having established this limit. Both the State of Utah and the District of Columbia permit 800 lb. per in. on tires over a certain width; in Utah, it is on tires over 5 in. and in the District of Columbia on tires over 7 in. Ten States have established a limit of 600 lb., and the remaining States have established limits falling below 600 lb. and between 600 and 800 lb.

Seasonal restrictions are in force in various States, where the load per inch of tire width is reduced during the early spring. Tire-load limitations are based, primarily, on solid tires, and are not practical in their present form for either the pneumatic or the balloon tire. This is clearly evidenced by the figures in Table 8 giving tire capacities per inch of nominal width in the larger sizes of balloon tires. In the popular sizes of the larger balloon tires, suitable for dual installations, capacities range between 309 and 495 lb. per in. of nominal width. While the N. A. C. C. has a recommended scale of tire loads, the National Code has eliminated all recommendations on load per inch width of tire. There is, apparently, no need for such regulations, as the solid tire is disappearing rapidly from modern highway-transport vehicles.

### Summary

The facts as presented so far clearly illustrate a situation similar to the one which existed during the early decades of railroad building, when a variety of rail gages was used and the rolling equipment was not interchangeable between the different railroads. A standard-gage track was eventually agreed on, but legislation did not interfere with that program of standardization.

As pointed out in my previous paper[2] on this same subject, our State Legislatures have erected 49 boundary lines preventing the free circulation of motor-vehicles from one State to another, as we do not find any two neighboring States having uniformity in regulations for sizes and weights of commercial motor-vehicles. Hence, vehicles which can be legally operated in one State are prohibited from crossing the State line into neighboring States due to difference in State regulations; therefore, such State laws interfere with the free movement of inter-State commerce.

The initial step toward securing a closer uniformity of laws governing maximum sizes and weights of vehicles was taken by the National Conference on Street and Highway Safety in 1926, when the original code was set up under the able leadership of President Herbert Hoover, then Secretary of Commerce and acting as Chairman of that Committee. The original Hoover code was amended in 1930 to meet better the changes in vehicles and highway construction; but very little has been accomplished so far in getting State Legislatures to adopt the new code. In fact, the legislative results of 1931 indicate that the situation is becoming more complicated.

It has also been definitely demonstrated in 1931 that National uniformity of regulations, the ultimate objective, cannot be achieved so long as highway transportation is regarded as an individual State problem. It has been suggested that some action may be taken by the Federal Government along the following lines.

(1) Classification of all highways by the United States Bureau of Public Roads from the highway engineers' viewpoint, in cooperation with the United States Army from the viewpoint of National defense.

(2) Action by Congress to limit the use of the Federal Aid Fund to the construction of primary highways only until a network of such National highways is completed. On all such primary highways, partly built with Federal-Aid-Fund money, vehicles of a specific size and weight as recommended in the National Code should be permitted to operate legally, regardless of individual State regulations.

Such action would be of inestimable value to the public in general, bringing about a lower cost of distribution for all the necessities of life.

As vehicle manufacturers are compelled to conform and change their designs to meet this great variety of State laws, production economies cannot be effected, because of the limited quantities of vehicles of certain types that are salable in only a few of the States. Dormant markets cannot be cultivated because laws restrict the sizes and weights and prevent the sale of heavy-duty vehicles in more than 20 States. Maximum economy in operating costs cannot be obtained by oper-

[2] See S.A.E. JOURNAL, September, 1930, p. 320.

ators, because they are prevented by legislation from using the most economical type of equipment to meet the requirements.

Compulsive and premature obsolescence caused by sudden changes in regulations—as happened in Texas in 1931, where hundreds of trucks must be junked on Jan. 1, 1932—is causing irreparable losses to operators, mounting into millions of dollars. Operators cannot decide on immediate purchases, as the uncertainty of future changes in the State laws may force them to discontinue operation of comparatively new and expensive equipment.

No other industry is facing uncertainties of this kind and, obviously, the time has arrived for the Society to take action and give serious consideration to setting up a standard on limitations of sizes and weights of vehicles, taking into consideration:

(1) Practical design limitations from the standpoint of the vehicle and tire manufacturers
(2) Safe and economical operation
(3) Limitations of pavement and bridge structure as set up by the United States Bureau of Public Roads
(4) Safety to the public on the highway

The United States Bureau of Public Roads, the National Conference on Street and Highway Safety, the Motor Vehicle Conference Committee and the National Automobile Chamber of Commerce are all striving for the same objective; namely, a standard, uniform, workable code along sane, safe and practical lines; a code the sound and basic fundamentals of which would enlist the support of our highway engineers, safety commissioners, manufacturers, and shippers' and operators' associations throughout the Country.

# Some Problems of the Motor-Transportation Executive

(*Concluded from p.* 434)

trained executive. The motor-vehicle manufacturer can do much to sell the idea of transportation engineering to the motor-vehicle user. He can go far toward getting the owner of a fleet of vehicles to hire a transportation superintendent. After this is done, the transportaion superintendent must produce in order to hold his job.

These days of business stress emphasize as never before the necessity for securing increased profits through increased economies.

The close attention by higher company executives to their automotive departments which is so obviously demanded is, unfortunately, not always to be found. Seemingly, the technical intricacies of scientifically applying motor-transport equipment to haulage problems are, to some, simply something to brush aside impatiently; others of these higher executives have a vague appreciation of the importance of automotive affairs but are afflicted with a species of swivel-chair inertia which causes them to put the matter off until "tomorrow." Fortunately, there are certain outstanding exceptions—major executives who personally study and grapple with these problems and who are profiting thereby in the many economies which aggressive analysis must always discover. *It is of extreme importance that the higher company executive arbitrarily allocate enough of his personal time to digest and learn thoroughly just what his motor-transport problems are.* As George Pride once said,

> I dare say there isn't a superintendent of a fleet operation . . . who is not burning with some ideas which, if he had an opportunity to put them into effect, would make a very substantial saving for his company. Yet he is unable to reach the ear of that person who could make it possible for him to make them effective.

The company executive, if he will but spend the right amount of time intelligently on this complex problem, cannot help but gain the complete understanding which is necessary if he is to reap the benefits of economies which can be achieved only as a result of his final authority. If he will *insist* upon a cost system which will tell him the facts, if he will appreciate the technical and business qualifications necessary to the proper fulfillment of the transportation-executive's job, then surely he will be more inclined to dignify that job with authority as well as responsibility, and with the recognition and the compensation which are demanded if real transportation economies are to accrue.

Some company executives have met their transportation superintendents, been badly impressed by their personalities, been confused by the complexities of the job, and have thereupon retreated to their inner sanctums and in effect have washed their hands of the whole matter. They really have got more out of an experience than there was in it. As Mark Twain once said: "A cat will sit on a hot stove once, but the trouble thereafter is that the cat will not even sit on a cold stove." Let the executive jump into the arena with both sleeves rolled up. He will find his time well spent.

### Recommendation and Conclusions

The problem dealt with in the preceding section is indeed a serious one in spite of the outstanding exceptions exemplified by some companies. No amount of speechmaking and table pounding, no use of high-powered adjectives, no oratory, will be as effective in the solution of this problem as the personal obtaining of the facts concerning his own company by the higher company executive. I suggest to the executive who has not been close to his motor-vehicle problems that he give himself an honest answer to the following self-questionnaire:

(1) What is my total motor-vehicle investment?
(2) What is my total annual expense for motor-vehicle operation, maintenance, fixed charges, and the like?
(3) How many units does my company own?
(4) How many units does my company rent? Why?
(5) Have I an *adequate* cost system for control of automotive activities?
(6) How does my expense per ton-mile, or other basis of measurement, compare with that of other companies in my line of business? How are my net profits affected thereby?
(7) Are the activities and responsibilities of my automotive personnel properly organized, coordinated and charted?
(8) Is my fleet superintendent properly qualified, technically and as a business executive?
(9) Have I given him sufficient authority to enable him to exercise adequate control?
(10) Do I consult with him frequently enough?

The problems which have been discussed herein are not academic problems. They are live, practical issues which must be met squarely. It is to be hoped that thorough and continuous discussion of them will be carried on. Benefits therefrom will become apparent.

# Instrumentation as a Means for Coordinating Chassis and Body Design

Semi-Annual Meeting Paper

By A. F. Denham[1]

INFORMATION as to the mutual adaptability of a chassis and body can only be determined experimentally, and each car model is an individual problem. Coordination is difficult because the chassis usually must be developed far in advance of the time when the body is designed.

Devices are described for subjecting cars and their major units to twisting stresses, and the application of instruments to measure and to integrate deflections are illustrated by examples.

Remedies of troubles may be found by stiffening or introducing flexibility at certain points or by a redistribution of masses. Rubber mounting of engines and rubber body-shims change conditions and add to the difficulty of the problem.

Experiences with some of the instruments described were reported in the discussion, and an instrument that has been developed for recording vibration amplitudes and frequencies on airplane instrument-boards was suggested for use on automobiles.

INSTRUMENTATION for coordinating chassis and body design should do one or both of two things: analyze a design for possible troubles or improvements needed, and indicate means for correcting the design or achieving the improvement.

It is true that some individual problems are characteristic of a great number of cars, but the conditions which produce the particular problem and the remedy needed in one case may be quite unlike those in another make or model.

The evolution of the average new model unfortunately does not lend itself to an initially coordinated body and chassis design. In most if not all cases, a general chassis design is achieved some months, if not a year or two, before consideration is given to the exact type of body which will be mounted on that chassis. Given a rough conception of the approximate appearance and dimensions of the body that eventually will be used, the chassis designer should be allowed time enough to assure himself that there is nothing mechanically unsatisfactory in the working parts of the chassis proper. Final body design on the other hand must in most cases await the proximity of the car-announcement date. During this interval the utmost cooperation is necessary between chassis and body engineers.

Whether a corrective change should be made in the frame or in the body will always be a question. This has been a major bone of contention in the industry for some time past. The answer has generally been a compromise, and often a compromise more unsatisfactory than either of the two primary possibilities might have been.

The use of empirical assumptions based on the success of any given design is a fallacy that has more often caused grief than it has resulted in a satisfactory product, the reason being that the factors which may have combined to give a satisfactory job in one case are not constants but variables.

### Equipment for Break-Down Tests

Instrumentation—or its substitute, observation—can be divided into two distinct classes: first, that needed to tell whether the combination of a specific body with a specific chassis will result in a satisfactory car; and, second, that needed to locate the source of troubles and determine the best manner of correcting them. The second group can be subdivided again into instruments for use in studying individual deflections and those dealing with periodic vibrations. The latter involve the introduction of the time element.

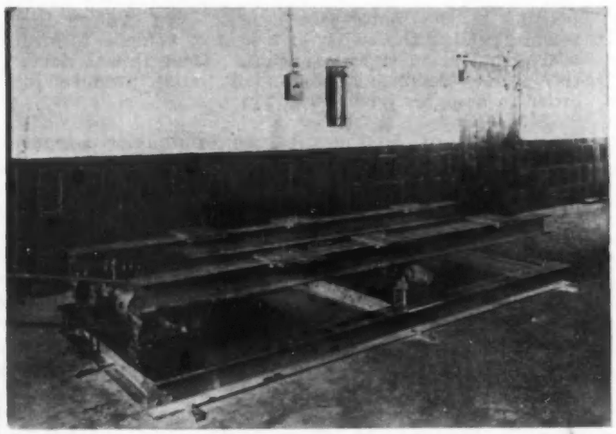


FIG. 1—BODY AND CHASSIS TESTER

The Beams of This Wiggler, Which Is Used at the General Motors Proving Ground, Are Rocked by Adjustable Eccentrics

Chassis tests alone or body tests alone are far from sufficient. It is perfectly feasible to build a satisfactory car with either chassis or body, or both, flexible or rigid, just as it is possible that each combination may be unsatisfactory.

It is largely a question of providing flexibility and rigidly where each is needed, and just where these points are located may vary from car to car and from one yearly model to the next. Perhaps even more important than flexibility or rigidity is the question of mass distribution and the means for making use of or minimizing the effect of inertia forces.

Two possibilities are open to the manufacturer to determine whether a given complete car design will prove satisfactory in service: road tests and accelerated break-down tests.

Road testing might possibly lead to somewhat erroneous conclusions, depending on the particular driving characteristics of the operators, while break-down tests may not actually duplicate service conditions. Together, however, they should make possible the drawing of fairly satisfactory conclusions.

[1] Field editor, *Automotive Industries*, Detroit.

Accelerated break-down tests should approximate as closely as possible somewhat exaggerated road conditions. Chassis dynamometers with cleats on the roller are most widely used for this purpose.

The "wiggler" used at the General Motors proving ground is shown in Fig. 1. It consists mainly of two steel beams mounted at the center on individual trunnion joints. At the front end there is a belt-driven shaft on each end of which are two eccentrics, one within the other, that can be adjusted to a maximum eccentricity of 3 in. The eccentrics are generally set so that the two beams will rock 180 deg. out of phase and impart a twist to the entire assembly. A good average speed at which to turn the eccentric shaft has been found to be 600 r.p.m. This is estimated to be equivalent to 1000 m.p.h.

Fig. 2 shows the installation with a chassis frame and body mounted thereon. For tests such as these only bodies and frames from production tools can be counted on to give reliable information. The difference in characteristics between apparently identical bodies or frames, according to whether they are made by hand or obtained from production tools and dies, is often astounding. It will be noted that the springs have been replaced by steel beams shackled to the frame and pivoted on the wiggler beams to eliminate variable factors such as spring interleaf friction and damping, and also to obtain a more severe test of the chassis and body with a small throw of the eccentrics. With this arrangement, a 5/16-in. throw for each set of eccentrics is generally used, giving a total relative movement of the front end of the beams of $\frac{5}{8}$ in.

Another installation used by General Motors in checking the results of its road testing is shown in Fig. 3. It is intended largely to provide an empirical means of locating and analyzing the squeaks and groans that develop in a test car with mileage. Each wheel rests on an individual platform vertically actuated by two slow-motion walking-beams, one for the front and one for the rear wheels. Each of these has a 9-in. stroke, with the right front and the left rear wheel up at the same time. Fig. 3 is a double exposure taken 180 deg. out of phase to show the effect of variation in front and rear-spring rates. With this installation an oil-can will effectively locate a great majority of the squeaks and groans developed.

### Instrumentation for Measuring Maximum Deflections

When conducting break-down tests on chassis rolls it is desirable to operate the equipment at a speed and with a setting to produce the worst conditions as to deflections that may be encountered in service. An effective way to accomplish this is to try the equipment at various speeds and select the speed giving the maximum deflections as measured by what, for lack of a better term, might be called an extensometer.

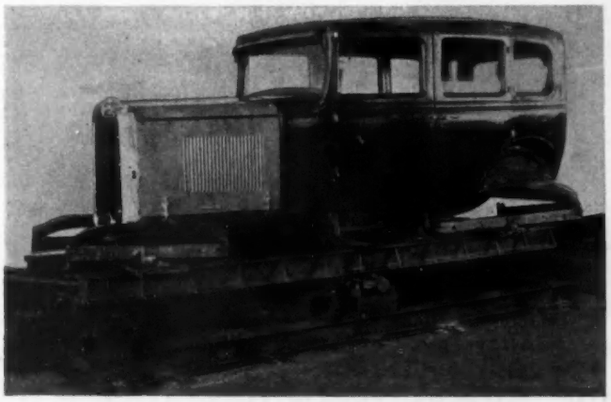


FIG. 2—CHASSIS AND BODY ON GENERAL MOTORS WIGGLER

Rigid Beams Are Substituted for the Springs

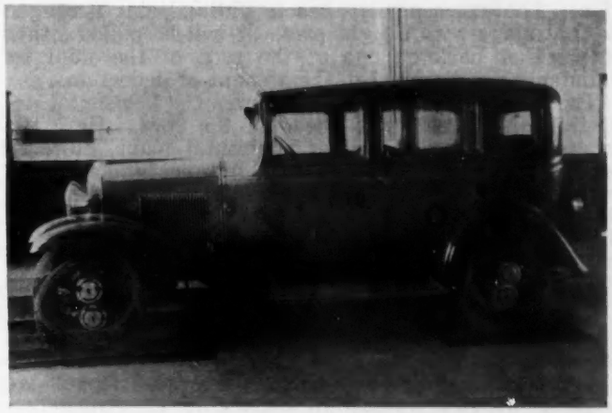


FIG. 3—SLOW-MOTION TWISTER FOR LOCATING NOISES

The Four Platforms Reciprocate Vertically, the Two Diagonally Opposite Each Other Going Up While the Other Two Go Down

Two forms of this popular instrument are shown in Fig. 4. The upper view shows the type in use by Dietrich, Inc. It is composed of two telescoping tubes actuating an arm through an amplification of about four or five to one. A pencil at the end of the arm traces a line back and forth on a piece of paper mounted on a suitable plate attached to the outer tube. An amplifying dial-type gage is sometimes substituted for the pencil-carrying arm.

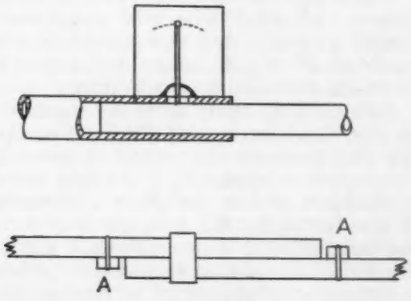



FIG. 4—EXTENSOMETERS FOR MEASURING FRAME DEFLECTIONS

The Device Shown in the Upper View, Used by Dietrich, Inc., Is Made from Tubes and Actuates a Pencil on a Multiplying Arm. The Lower View Shows a Lighter Device, Made by the Fisher Body Corp., from Grooved Pieces of Wood and Rubber Bands, Which Is More Suitable for Road Tests

While the tubular type of extensometer is satisfactory for the determination of maximum amplitudes of deflection on chassis rolls, it is not as satisfactory for road testing, because of the inertia of the moving parts. The lower view in Fig. 4 shows the extensometer as worked out for road tests by the Fisher Body Corp. Small blocks of wood are held to grooved wooden beams by ordinary rubber bands. The extensometer is placed diagonally in the body.

When there is a reduction in the diagonal of the rectangle being investigated for deflection, the wooden blocks will be pushed away from their original position and the maximum amount of change in the diagonal can be readily determined.

Use of the extensometer, however, is not limited to body deflections. Fig. 5 shows how the same idea is used by Hupmobile to study frame side-rail deflections on the road. Three extensometers are used. One measures the angular deflection of the frame ahead of the cowl with reference to the frame at the back of the cowl. This extensometer is located between tubular triangles above the frame side-rail, to amplify the mo-

tion. The extensometer has a sliding joint arranged so that rings with a light press fit will be pulled either forward or back on one of the rods of the joint by a distance proportional to the amount of deflection.

The second extensometer measures the horizontal deflection of the side rail ahead of the cowl. Here the triangles are mounted in a horizontal plane, suitably braced so that the reading will not be influenced by movement of the structure under its own weight. The third unit measures the deflection at the rear end of the front kick-up. These instruments aid in the determination of the maximum amplitudes of deflection.

### Integrating Instruments

Many body noises result from the summation of smaller deflections rather than occasional maximum deflections. Apparently very little has been done in the way of developing instrumentation to determine the frequency or periods of deflections in either chassis or body.

The H. H. Franklin Mfg. Co. is carrying on some interesting experiments, using an extensometer of the pencil-arm type that makes a record on a revolving drum having a circumference of about 6 in. The timing device was obtained from a recording thermometer, the escapement mechanism of which was replaced by a small fan acting as a brake to give the desired speed of 10 sec. per revolution of the drum.

Tests are carried out on a 1/20-mile straightaway portion of what Franklin engineers refer to as the "creek drive," used for production testing. Runs are made at 20 m.p.h., allowing just enough time for one complete revolution of the drum.

Pedometers, such as those used by hikers, are used by the Studebaker and Packard companies as integrating instruments to study movement. The common pedometer consists of a weight pivoted to a ratchet mechanism which registers the number of steps taken in the form of total mileage. By removing the adjusting hairsprings, which normally limit the amplitude of the swinging of the weight, the pedometer can be used to integrate total amount of movement, three unit movements giving the same reading as a single movement three times as great. Since, without the hairsprings, the instrument has its maximum sensitivity in one direction only, it can be mounted in various positions to measure the movement in any given direction.

Fig. 6 shows two pedometers, one mounted on the radiator cap and one on the head-lamp tie-rod of a Packard. If this particular test could be used only to tell the relative amount of movement between the head-lamp tie-bar, including the fenders, and the radiator, that alone would be valuable; and it can be used also for direct comparative checks, before and after making a modification in design, to determine the effect of that change on the stability or movement of the unit being tested. It is necessary to standardize the conditions of the test, and a sufficient number of readings must be obtained to give a good average.

Another integrating device used by the Studebaker Corp. is shown in Fig. 7. It consists of three Veeder counters arranged so that the first one registers when the amplitude of relative movement between tie-bar and radiator is say $\frac{1}{8}$ in. The first and the second would register when the amplitude was 3/16 in., and all three would register for a movement of $\frac{1}{4}$ in. or greater.

Other devices for checking radiator wabble have been observed, some depending on visual sighting and some on an arrangement of strings and pulleys actuating a pencil-carrying arm as in the extensometers. These do not integrate the total movement.

### Mass Distribution and Inertia Studies

Basically there are deflections of two kinds in a chassis or body: shock deflections and periodic or synchronous vibration or deflection. The factors which enable a design to resist or minimize the first are mainly rigidity and its antithesis, flexibility. Mass distribution and inertia effects largely control the latter.

Movement of body pillars, for instance, is affected by inertia. Several manufacturers are at present using diagonal tension-wire bracing across the roof to reduce movement at the pillars by making the roof a more rigid brace. A Studebaker engineer, to check the tension required at this point, ran light wires diagonally across the roof and over suitable supports down to a scale, with means for applying tension through the scale. It was found that a surprisingly small amount of tension was required to obtain the desired bracing effect.

One important thing to remember in attempting to measure body movements with mechanical equipment is to see that the equipment itself does not upset the conditions of the test. At one factory it was desired to study front-end shake and cowl movement, as experienced on the road, with the car mounted on chassis rolls. Anchor frames were attached to both front and rear axles. When the test was started, the shake seemed to have entirely disappeared. Upon changing the attachment so that the weight on the front axle was decreased, the shake reappeared, doubled in viciousness.

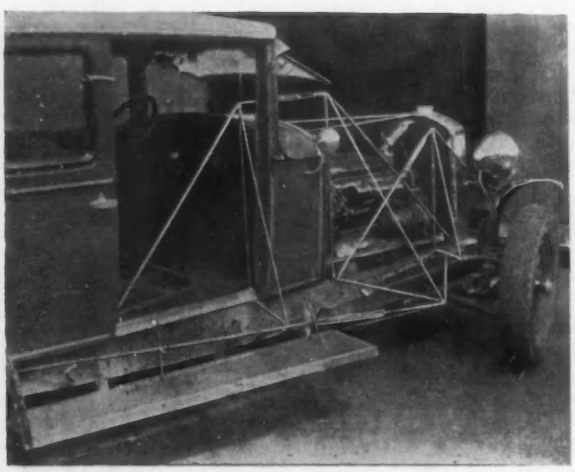


FIG. 5—EXTENSOMETERS APPLIED TO HUPP CHASSIS TO MEASURE DEFLECTIONS AT THREE POINTS

FIG 6—MODIFIED PEDOMETERS FOR INTEGRATING HORIZONTAL MOVEMENTS OF RADIATOR CAP AND HEAD-LAMP TIE-BAR

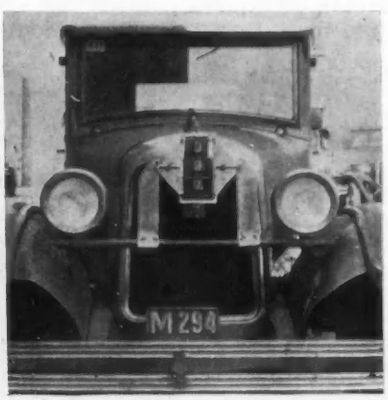



FIG. 7—COUNTERS MOUNTED TO RECORD THE NUMBER OF DISPLACEMENTS OF VARIOUS AMPLITUDES BETWEEN THE RADIATOR SHELL AND THE TIE BAR

This indicated that the radiator shake in this car was a direct function of mass distribution or inertia effect. Any given chassis and body assembly has natural frequencies of vibration, running rather uniform in any given model but varying frequently with the type of body model.

The adoption of rubber engine-mountings has been a source of grief to many car designers in this respect, when such mountings are used in approximately the same location as former rigid mountings. In addition to reducing the torsional rigidity of the frame by the elimination of the crankcase as a cross-member, there is also a decrease in polar movement of inertia of the front end. It is possible to overcome the latter effect by the nature and location of the engine mountings, as in the new Plymouth.

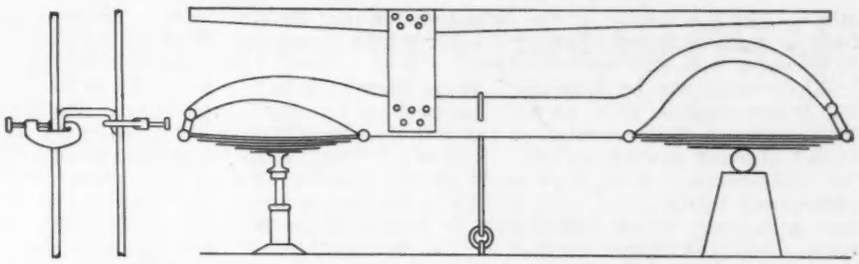


FIG. 8—GRAHAM-PAIGE SET-UP FOR MEASURING DEFLECTIONS IN FRAME
The Small View Shows How Flange Deflections Are Measured

### Controlling Radiator Shake

A device to which a number of manufacturers have resorted, to steady the front end, is mounting the radiator flexibly in the frame and then attaching a brace to the radiator shell at one end and the fender tie-bar or fender itself at the other end. This virtually adds the mass of the radiator, with the water it contains, to the front-end-inertia mass, with a considerably increased lever arm because of its location well above the frame. On one Nash model this brace includes a small friction damper in the assembly, to help in damping front-end movements.

A method occasionally used to decrease front-end movements is the addition of weight at the bumper ends. On the car shown in Fig. 5, such a weight was mounted experimentally well out along a section representing the front bumper. It was fairly effective in reducing front-end shake and frame and body deflections.

No instruments have been so far developed, to my knowledge, which in themselves will determine the characteristic or fundamental period of vibration of any given car. Such an instrument would need to be able to distinguish fundamentally between pure shock deflections and actual induced deflections or vibrations. However, it is entirely possible and limited experiments seem to indicate the probability that any reduction in induced vibration will generally result in a reduction of shock deflections. Shimmy, tramp and front-end shake apparently are all torsional vibrations, and changes to correct these troubles may produce, for instance, greater torsional stability of the car as a whole.

Stroboramas or stroboscopes have been used by a number of companies, including Packard and General Motors, to determine the worst vibration periods. Any number of simple devices are available to determine the amplitudes of these periods. A method used by Studebaker consisted of placing chalk marks on body panels and other points and measuring the movement, with the body on rolls. Another method is through the use of time-exposure photographs. For this purpose, General Motors engineers paste on the body a number of rings of the type used to reinforce the leaves of loose-leaf books. On a time-exposure photograph taken with the car on a "Belgian roll," a simple microscope or reading glass shows the amplitude and direction of displacement as an elongation of the rings, or an apparent halo at one side or another. The possibilities inherent in taking motion pictures with the aid of the stroborama, if such equipment were available, are interesting to consider. Slow-motion pictures might also be helpful.

An expedient which was found useful some time ago by Studebaker engineers in making torsional-rigidity studies of frames and of frame and body assemblies consisted of making paper or cardboard models of frames and bodies and subjecting these to torsional tests. Comparative tests with full-scale models indicated rather good agreement. This method might be found useful in the evolution of a new car.

Torsional-rigidity checks are rather widely used in the industry. The most common way is to anchor down three corners of the frame or car and jack up the other corner with the jack on a scale, thereby measuring the deflection rate per pound of thrust.

Fig. 8 shows a set-up used by Graham-Paige engineers for checking side-rail-deflection characteristics. The frame was anchored at the center, the rear axle was rested on a suitable support, and the front axle was jacked up successively to three positions, one with the springs compressed to the fully loaded-car position, one with the springs touching the rubber bumper, and one in metal-to-metal contact. A bracket carrying a wooden beam extending the length of the frame side-rail was attached to the frame side-rail over the anchor. The deflection curve could be plotted by measuring the distance between the beam and the side rail, at various points. Transverse rods were also attached to the upper and lower side-rail flanges, so that the deflection of these flanges could be amplified and measured at the ends of the rods, especially at the kick-ups. Incidentally, deflections as great as 9/16 in., measured 3 ft. out. were found in the side-rail flanges. By deepening the side-rail web at the center section, where the maximum deflection was found, and removing an equivalent amount of metal from the side-rail flanges, without the addition of metal, a side rail was designed that has what are regarded as considerably more satisfactory deflection characteristics.

A similar installation is used by the Murray Corp. of America to check side-rail deflection on the road. In this case the beam is attached to both front and rear ends of the frame, and arms with pencils at their upper ends are attached to the side rail to record the amount of movement on sheets of paper attached to the beam.

Spirit levels graduated in angular units have been used also to study small frame-deflections, both transverse and lengthwise, and protractors are used for the measurement of larger deflections.

Studies of frame deflections on the road apparently have not been given much consideration. Such investigations probably would simplify the problems of the body designer in knowing just where rigidity is needed and where flexibility should be provided.

Aside from vertical deflections of the frame side-rail, there is the possibility of side-rail weave between cross-members; there may be lateral displacement of the side rails at the front end of the frame and other deflections. Possibly some type of inertia instrument to measure the total movement might be used for road work to check these items. Another possibility is a system of pulleys and string leading to an amplifying and recording device. Still another is the use of overhead beams, located either longitudinally or transversely, with pencil recorders, dial indicators, or counters of some form or

other. The application of the extensometer idea in the form of a suitably amplified protractor might be of use in checking side-rail weave.

While much can be done along these lines in obtaining better frames, this can only be part of the story. No sooner is a body mounted on the frame and the body bolts tightened down than deflections are set up. Rubber body-shims, which apparently seemed headed for widespread introduction only a little more than a year ago, have been found undesirable in a number of instances and abandoned, because of the decreased effectiveness or destroyed coordination of the body sill and side rail acting as a unit and the service troubles experienced. Mechanics who are ordered to tighten all bolts are inclined to be rather conscientious about pulling down tight on the bolts passing through rubber shims, thus providing the repair shop with another job of correcting misalignment when doors no longer close well.

When the entire problem of chassis and body coordination is considered in view of the limited instrumentation available at present for its study, it is apparent that in many cases possible sources of troubles can be found as quickly by a trained observer as they can by the instruments available. Selling the management on the changes necessary to correct the troubles is another question. Instrument records in black and white are hardly as much subject to argument as are individual impressions in judging the value of a change in design.

The correction for any given deflection trouble may be found in one of three ways: strengthening, weakening or damping. Strengthening, as by increase in side-rail strength, may sometimes reduce the amplitude but increase the viciousness of the deflection. Weakening, as by the adoption of flexible joints in body structure, may be open to questions of desirability. Damping, as by the changing of inertia moments or redistribution of masses, may involve considerable changes in design or some rather unusual departures. One of the three, however, will have to be used; which one depends on the specific problem and the specific car. There is no cure-all for any given problem, just as there probably can be no one instrument which effectively will analyze all problems.

## THE DISCUSSION

CHAIRMAN L. C. HILL[2]:—We have found records from the device shown in the upper portion of Fig. 4 to have important shortcomings because they do not indicate the frequency or period of body movements, without which the results are not very conclusive. In a certain case we found that records made before stiffening the body under test showed a pencil line about 2 in. long. The line was very black throughout its entire length, indicating that the movement was taking place most of the time. After bracing was added in the body, the pencil line on the record was still about 2 in. long. However, we noted an important difference; the pencil line was very dark in the center of the travel and lighter in shade toward the ends. We concluded that the extreme movement was as great or nearly as great after bracing as before, but that the movement was to the extreme only a small part of the time. This checked with visual observation, because the body seemed to move much less violently after the addition of the braces.

We concluded from this experience that the time element should be included in the record by having the paper move either at a constant speed or at a speed related to the car speed. With a record made in this way, it could readily be seen whether the frequency of the movements in the body was changed by change in the body structure.

E. S. MARKS[3]:—The instrument of ours which Mr. Denham has described was born of necessity, like many other instruments. Until we put the clock mechanism on it, we found that the results were very hard to interpret. Looking at the present records, we may find that the maximum deflection is the same after the change as it was before, but in one case the maximum deflection may occur only twice in 10 sec., and in the other case 8 or 10 times.

FREDERICK S. DUESENBERG[4]:—Much has been said about stiffening the frames. The most important thing is to find where the trouble starts. I think that the source of the trouble is the weight of the wheels and the axles; what is needed is much less weight in those parts, then the springs can be lighter and the amount of shock transferred to the frame can be less. If some of the effort that has been put into the application of instruments to show the relations between the body and the frame were applied to a study of the relations between the axle and the frame, much of the trouble would be avoided.

CHARLES H. COLVIN[5]:—An instrument has just been developed by my company for recording and measuring the vibration amplitudes and frequencies on the instrument-boards of airplanes. We shall be glad to cooperate in determining whether or not the instrument is useful on automobiles.

R. F. ANDERSON[6]:—Body designers will be glad to know that chassis engineers are interested in the relation of the frame to the body and in stiffening the frames. A great deal of expense would be saved if the chassis were built rigid, thus saving the costly corrections of the troubles which are revealed by these tests.

MAURICE OLLEY[7]:—Rubber mounting of engines seems to have an effect similar to that of putting a harmonic balancer on a crankshaft. It does not necessarily increase damping, but it does produce two resonance frequencies instead of one.

HERBERT CHASE[8]:—I know of some highly promising experiments that involve mounting the chassis on three points in such a way that body-racking stresses are minimized. In such a design, deflection of the wheels does not twist the body, and a less rigid frame and body should be practicable and should result in considerable saving in weight. This seems likely to produce better results than proposed constructions in which the body has a three-point support on the frame. Both, however, are promising developments which should help to stop the tendency to add excessive weight to build a structure stiff enough to withstand twisting strains that ought not to be imposed and would not be imposed with three-point support. I am aware that some engineers are opposed to any such scheme and that it involves some disadvantages; but the latter, in my opinion, are outweighed by the advantages.

H. T. WOOLSON[9]:—Experimental chassis have been built with a single point of support in front. The effect is unpleasant, because the body lists when going around a curve.

---

[2] M.S.A.E.—President, general manager, Dietrich, Inc., Detroit.
[3] M.S.A.E.—Chief engineer, H. H. Franklin Mfg. Co., Syracuse, N. Y
[4] M.S.A.E.—Vice-president in charge of engineering, Duesenberg, Inc., Indianapolis.
[5] M.S.A.E.—President, general manager, Pioneer Instrument Co., Inc., Brooklyn, N. Y.
[6] M.S.A.E.—Sales engineer, Murray Corp. of America, Detroit.
[7] M.S.A.E.—Engineer, Cadillac Motor Car Co., Detroit.
[8] M.S.A.E.—Consulting engineer, Forest Hills, N. Y.
[9] M.S.A.E.—Chief engineer, Chrysler Corp., Detroit.

# Fuel-Line Temperatures in Cars of 1931[1]

Semi-Annual Meeting Paper

By Oscar C. Bridgeman[2] and Hobart S. White[3]

THE PRESENT PAPER covers the results obtained in a second survey of fuel-line temperatures. Road tests were made on a large number of 1931 cars operated under various specified conditions, and fuel temperatures were measured in each case at several points in the fuel-feed system. On the average, no material improvement over the 1930 models was found. Individual models had been improved considerably, while others had become worse. This unchanged situation may be due, in part, to the fact that the results of the 1930 survey were not available in time so that full advantage could be taken of the conclusions in designing the 1931 models.

Reasonable protection for most of the 1931 cars as regards fuel cannot be obtained in hot weather if they are run on gasolines having a Reid vapor pressure higher than 7 lb. per sq. in. The production of such a product not only makes difficult the meeting of the requirements necessary for easy engine starting during some seasons of the year but, in addition, materially curtails the available supply of suitable gasoline. The problem of eliminating vapor lock would be greatly simplified in the case of forthcoming models if these cars were equipped with well-designed fuel-feed systems; in fact, such a change in design is the only way of eliminating a large percentage of the vapor-lock troubles. The problem is not very difficult from the design standpoint, and some of the 1931 cars have satisfactory fuel systems. Effective installation of the line leading from the gasoline tank to the fuel-pump, and changes in the position and in the method of lubrication of the fuel-pump, appear to be the two major points involved in solution of the problem.

BOILING of gasoline in the fuel-feed system may cause interruption of fuel flow with resultant engine stoppage. This phenomenon is known as vapor lock and its occurrence is a source of considerable annoyance to the motorist, for usually it is necessary to wait until the fuel line has cooled off before the engine can be started again. The higher the vapor pressure of the gasoline is, the lower is the temperature at which boiling begins. Thus vapor pressure is the property of a gasoline which determines the boiling temperature and hence the vapor-locking tendency. In any given automobile operated under any chosen set of conditions, the fuel with the lowest vapor pressure can stand the greatest amount of heating before vapor lock occurs. On the other hand, a gasoline which is satisfactory in one automobile may give trouble in another automobile due to differences in design of the fuel-feed systems and consequent differences in the amount of heat imparted to the gasoline while flowing through the feed system. Similarly, a gasoline which is satisfactory in cool weather may give trouble from vapor lock in warm weather. Altitude likewise has an effect, for in elevated regions the temperature at which boiling occurs is lower than at sea level.

Accordingly, the four factors which affect vapor lock are: (*a*) vapor pressure of the gasoline, (*b*) design of the fuel-feed system, (*c*) atmospheric temperature, and (*d*) altitude. Whereas vapor pressure determines the temperature at which boiling will occur at any given altitude, the atmospheric conditions and the design of the fuel-feed system determine whether the gasoline will be heated to its boiling temperature in service.

Of the foregoing four factors, the two which can be controlled or modified are gasoline vapor pressure and fuel-system design. In general, the refiner is controlling gasoline vapor pressure on the basis of service conditions, namely, the atmospheric temperature and the type of equipment in which the fuel is to be used, and probably this control will always be necessary. By reducing the vapor pressure to a low value, vapor lock can be almost entirely eliminated in very hot weather even with the present design of fuel-feed systems, but such control of vapor pressure materially reduces the percentage of suitable gasoline available. During the spring and fall, however, vapor lock cannot be eliminated entirely in current automobiles, for a winter gasoline may cause vapor lock while a summer gasoline may cause difficulty in engine starting. Therefore, especially during this period, a compromise between vapor pressure and ease of engine starting is necessary because of the variability of weather conditions.

The refiner can go part way by minimizing the propane content of the gasoline, but this is not all that is necessary. The automobile manufacturer should equip cars with cooler fuel-feed systems, and a few simple changes in design will produce a lowering of many degrees in fuel temperature. When temperatures in fuel-feed systems are only a few degrees above atmospheric temperature and when gasolines are free from propane, considerable increases in vapor pressure can be made even in very hot weather and still ensure complete freedom from vapor lock. Some car manufacturers have taken steps to redesign fuel systems and others unquestionably will follow shortly, but vapor lock will continue to be a problem until the majority of the cars now in service have been replaced or redesigned.

The foregoing general conclusions are based upon the work which the Bureau of Standards has been doing on the vapor-lock problem during the last two years under the auspices of the Cooperative Fuel-Research Steering Committee.

## Vapor Pressure and Vapor Lock

Since vapor lock is a result of boiling of the gasoline in the fuel-feed system, the first step in the general investigation of the problem was the determination of the method of measuring vapor pressure which would give results that were significant as regards vapor lock.

[1] Publication approved by the director of the Bureau of Standards of the Department of Commerce, City of Washington.

[2] S.M.S.A.E.—Research associate, Bureau of Standards, City of Washington.

[3] Junior physicist, Bureau of Standards, City of Washington.

A precision vapor-pressure method[4] was developed at the Bureau of Standards for this purpose and was found to be satisfactory. However, the measurement of true vapor pressure is an involved procedure and investigation[5] showed that vapor pressures by the Reid method on all types of fuels gave satisfactory agreement with the gas-free values when the former were multiplied by the factor 1.1 to correct for the larger volume of vapor space employed in the Reid method. Analysis of the general relations deduced in the study of vapor pressures, by methods outlined in the Appendix, indicated that the vapor-locking temperature $t$ in degrees fahrenheit of a gasoline was related to the Reid vapor pressure $p_R$ in pounds per square inch by means of the equation

$$t = 259 - 140 \log p_R \qquad (1)$$

Equation (1) represents a general relation between Reid vapor pressure and vapor-locking temperature, requiring a vapor-pressure measurement only at 100 deg. fahr. and involving two assumptions; namely, that the gasoline has a conventional distillation curve and that equal volumes of vapor and liquid can be handled by the fuel system before vapor lock occurs. Rigorous adherence to the conditions involved in these two assumptions is not essential for the accuracy required in the present work. This equation has been tested by numerous experiments in laboratory fuel-system installations[6], by road tests at the Bureau of Standards, and has been corroborated by Burk[7]. Throughout the remainder of this paper, when the term "vapor pressure" is used, it will be understood to mean Reid vapor pressure at 100 deg. fahr.

### Altitude and Vapor Lock

Equation (1) applies specifically to vapor lock during engine operation at sea level. At higher altitudes the vapor-locking temperature will be lower because of the decrease in atmospheric pressure. For the same gasoline-vapor pressure, the vapor-locking temperature at 10,000 ft. is 22 deg. fahr. lower than at sea level. The drop in vapor-locking temperature with altitude up to about 10,000 ft. is almost linear, being on the average 2.2 deg. fahr. per 1000-ft. increase in altitude.

Of more interest, however, is the consideration of how much lower the vapor pressure must be for use at 10,000 ft. to give the same protection from vapor lock as at sea level. Although the atmospheric temperature on the ground at 10,000 ft. is normally lower than at sea level, an automobile engine usually heats up more when operating in elevated regions. Therefore, the fuel temperatures are not much lower than at sea level. If $p_R$ is the permissible Reid vapor pressure of a gasoline for use in engine operation at sea level, and if $p_{R_1}$ is the vapor pressure of the gasoline which will give the same protection from vapor lock at any altitude, then at 10,000 ft. $p_{R_1} = 0.691\ p_R$. The analogous relation for operation at 5000 ft. altitude is given by the equation $p_{R_1} = 0.833\ p_R$. These relations are deduced in the Appendix.

Thus, if a gasoline having a vapor pressure of 8.0 lb. per sq. in. is permissible for sea-level operation, at 5000 and 10,000 ft. altitude the permissible vapor pressures are 6.7 and 5.5 lb. per sq. in., respectively. Graphical representation of the relation between permissible Reid vapor pressure and vapor-locking temperature is shown in Fig. 1, there being one line each for sea level, 5000-ft. and 10,000-ft. altitude.

[4] See S.A.E. JOURNAL, May, 1929, p. 488.
[5] See S.A.E. JOURNAL, July, 1930, p. 93.
[6] See S.A.E. JOURNAL, August, 1930, p. 217, and October, 1930, p. 443.
[7] See S.A.E. JOURNAL, May, 1931, p. 572.
[8] See S.A.E. JOURNAL, March, 1931, p. 315.

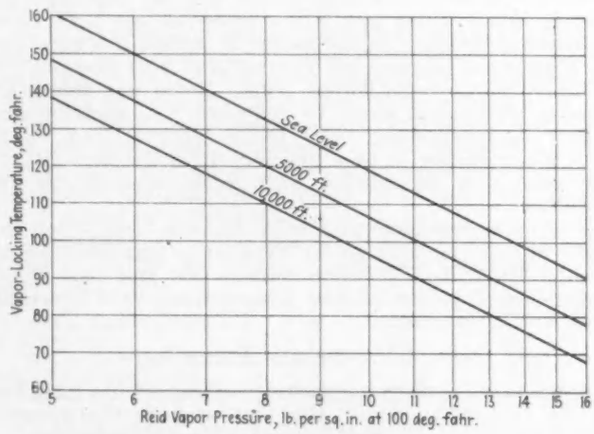



FIG. 1—CHANGE OF VAPOR-LOCKING TEMPERATURE WITH REID VAPOR PRESSURE AND WITH ALTITUDE

### Atmospheric Temperature and Vapor Lock

The relation between the Reid vapor pressure and the vapor-locking temperature expressed in Equation (1), modified if necessary for altitude, gives the predicted conditions for vapor lock with any commercial fuel having a conventional distillation curve. This makes it possible for the refiner to control the vapor pressure of his product if he knows the temperatures which the fuel is likely to reach in service. However, very little information has been available on the fuel temperatures in automotive equipment. Accordingly, during the summer of 1930, a survey[8] of fuel-line temperatures was made by the Bureau and several cooperating laboratories. The data proved of sufficient interest to warrant a second survey by the Bureau on 1931 cars.

The procedure adopted in making the test runs and the instrumentation were the same as those used in the previous survey. With all cars, constant-speed runs at three different speeds were made. For 12 of the cars, speeds of 20, 40 and 60 m.p.h. were employed. With the remaining cars, speeds of 20, 30 and 40 m.p.h. were used. In most cases, runs were made in both directions to minimize the effect of wind velocity and direction. Each constant-speed run was of such duration that the temperature at each of the selected points in the fuel system reached a constant value. After each constant-speed run, the car was drawn over to the side of the road and the engine allowed to idle with the gears in neutral until the temperature at each point reached a maximum value and started to drop.

In the case of the fuel-pump and the vacuum-tank systems, temperatures were measured at the fuel-tank outlet, the pump or vacuum-tank inlet, the pump or vacuum-tank outlet, and the carbureter inlet. With gravity-feed systems, temperatures were measured at the tank outlet, sediment-bowl outlet (if so equipped) and carbureter inlet. Nickel resistance thermometers inserted in special fittings in the fuel system were employed for the temperature measurements. During each run the atmospheric temperature was observed periodically.

Data were obtained on 47 models of 1931 cars. Of this number, 2 had gravity-feed systems, 5 had vacuum-tank systems and the remaining 40 had fuel-pump systems. All results were expressed as temperature increase of the fuel above the atmospheric temperature, since it had been found that, over fairly wide limits, the temperature increase of the fuel above the atmospheric temperature is independent of the particular atmospheric temperature existing during the run. These data are shown in Table 1 for a speed of 40 m.p.h. and for idling after a run at this speed. The averages of

TABLE 1—SUMMARY OF TEST DATA AT 40 M.P.H., IN DEGREES FAHRENHEIT

| Car | Fuel System | Atmospheric Temperature | Tank Outlet | | Pump or Vacuum-Tank Inlet | | Pump or Vacuum-Tank Outlet | | Carbureter Inlet | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 40 M.P.H. | Idling | 40 M.P.H. | Idling | 40 M.P.H. | Idling | 40 M.P.H. | Idling |
| 1 | MP[a] | 80 | 16 | 16 | 35 | 43 | 45 | 63 | 49 | 73 |
| 2 | MP | 70 | 19 | 22 | 30 | 66 | 31 | 78 | 35 | 56 |
| 3 | MP | 85 | .. | .. | 45 | 49 | 58 | 66 | 53 | 56 |
| 4 | MP | 80 | 21 | 21 | 25 | 41 | 33 | 54 | 33 | 45 |
| 5 | MP | 75 | 21 | 21 | 28 | 53 | 42 | 71 | 40 | 71 |
| 6 | Vac. | 70 | .. | .. | 24 | 50 | 32 | 52 | 37 | 57 |
| 7 | Vac. | 75 | 23 | 34 | 30 | 58 | 41 | 62 | 55 | 70 |
| 8 | MP | 80 | 13 | 16 | 34 | 56 | 44 | 73 | 39 | 63 |
| 9 | MP | 95 | 19 | 22 | 40 | 55 | 50 | 68 | 50 | 68 |
| 10 | MP | 75 | 14 | 17 | 4 | 27 | 28 | 61 | 42 | 59 |
| 11 | MP | 85 | 16 | 18 | 28 | 39 | 44 | 64 | 56 | 73 |
| 12 | MP | 90 | 13 | 15 | 38 | 54 | 37 | 65 | 38 | 61 |
| 13 | MP | 85 | 17 | 19 | 40 | 60 | 41[b] | 74[b] | 41 | 67 |
| 14 | Grav. | 85 | 16 | 17 | .. | .. | 26 | 45 | 32 | 57 |
| 15 | MP | 85 | 19 | 19 | 29 | 52 | 39 | 69 | 38 | 70 |
| 16 | Vac. | 90 | 26 | 28 | 33 | 79 | 43 | 68 | 39 | 80 |
| 17 | MP | 90 | 22 | 28 | 43 | 60 | 57 | 83 | 59 | 81 |
| 18 | MP | 95 | 22 | 25 | 32 | 51 | 54 | 74 | 49 | 72 |
| 19 | MP | 90 | 11 | 11 | 18 | 34 | 27 | 50 | 32 | 67 |
| 20 | MP | 85 | 21 | 25 | 26 | 37 | 32 | 53 | 45 | 69 |
| 21 | MP | 85 | 21 | 21 | 37 | 54 | 50 | 74 | 46 | 67 |
| 22 | MP | 85 | 22 | 24 | 44 | 71 | 67 | 88 | 46 | 74 |
| 23 | MP | 90 | 21 | 22 | 26 | 41 | 35 | 56 | 32 | 69 |
| 24 | MP | 90 | .. | .. | 27 | 37 | 35 | 55 | 34 | 74 |
| 25 | MP | 70 | 19 | 22 | 26 | 46 | 40 | 71 | 38 | 58 |
| 26 | MP | 80 | 27 | 27 | 27 | 40 | 44 | 66 | 46 | 63 |
| 27 | MP | 85 | 31 | 32 | 38 | 72 | 53 | 92 | 53 | 94 |
| 28 | MP | 80 | 16 | 18 | 26 | 44 | 41 | 55 | 38 | 51 |
| 29 | MP | 85 | 19 | 20 | 27 | 32 | 32 | 42 | 28 | 53 |
| 30 | MP | 80 | 18 | 21 | 37 | 45 | 57 | 72 | 52 | 78 |
| 31 | MP | 75 | 16 | 17 | 29 | 66 | 39 | 91 | 37 | 85 |
| 32 | MP | 80 | 19 | 21 | 29 | 59 | 42 | 79 | 40 | 76 |
| 33 | MP | 70 | 13 | 14 | 24 | 58 | 33 | 77 | 33 | 72 |
| 34 | Grav. | 75 | 54 | 80 | .. | .. | .. | .. | 33 | 45 |
| 35 | MP | 80 | 16 | 17 | 36 | 56 | 49 | 71 | 54 | 66 |
| 36 | MP | 75 | 14 | 16 | 29 | 35 | 46 | 52 | 57 | 65 |
| 37 | MP | 80 | 21 | 22 | 39 | 54 | 34 | 74 | 67 | 76 |
| 38 | MP | 75 | 24 | 25 | 32 | 57 | 41 | 68 | 38 | 65 |
| 39 | Vac. | 80 | 16 | 17 | 21 | 39 | 25 | 39 | 35 | 56 |
| 40 | MP | 85 | 15 | 17 | 33 | 49 | 41 | 64 | 38 | 58 |
| 41 | MP | 85 | 21 | 22 | 35 | 60 | 50 | 74 | 38 | 62 |
| 42 | Vac. | 70 | 11 | 11 | 24 | 47 | 24 | 34 | 55 | 69 |
| 43 | MP | 80 | 18 | 19 | 39 | 41 | 52 | 55 | 51 | 60 |
| 44 | MP | 80 | 18 | 21 | 34 | 48 | 49 | 66 | 50 | 66 |
| 45 | MP | 90 | 22 | 23 | 38 | 47 | 53 | 63 | 53 | 68 |
| 46 | MP | 85 | 16 | 17 | 27 | 28 | 37 | 50 | 42 | 63 |
| 47 | MP | 90 | 16 | 17 | 39 | 50 | 49 | 70 | 50 | 71 |

[a] MP—Fuel-pump.
[b] Sediment-bowl outlet.

the temperature increases corresponding to the various points in the fuel-feed system, for all cars equipped with fuel-pumps, are shown graphically in Fig. 2 as a function of the car speed. The speed indicated on the plot of idling temperatures refers to the car speed prior to the idling period. In the case of the constant-speed runs, it is seen that the temperature increases slightly with increase in car speed, while on idling the increase with car speed is more marked.

Laboratory work at the Bureau of Standards has indicated that, normally, the temperaturers at the following points are of major importance in determining whether vapor lock will occur:

In pump systems, at the fuel-pump inlet
In vacuum-tank systems, at the vacuum-tank outlet
In gravity-feed systems, at the sediment bowl or tank outlet.

The temperature increases above atmospheric temperature at these points for the 47 cars are given in Table 2 for 20 and 40 m.p.h., and for 60 m.p.h. in cases in which runs were made at this last speed. Data both at these constant speeds and on idling after runs at these speeds are included. In the second column, the fuel system of each of these cars is classified and, in the third column, the average atmospheric temperature during the runs on each car is listed. At a constant speed of 40 m.p.h. the temperature increases

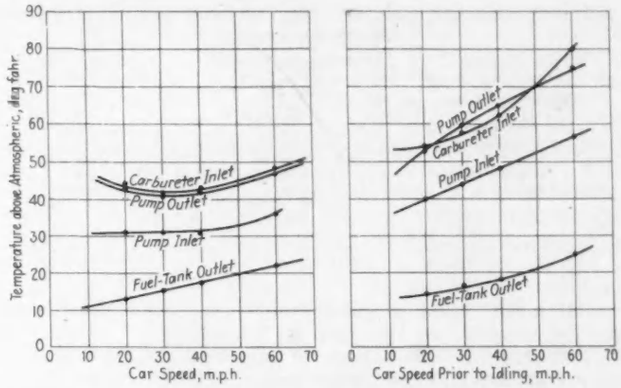



FIG. 2—EFFECT OF SPEED ON AVERAGE FUEL-LINE TEMPERATURES OF CARS TESTED

range from 4 to 54 deg. fahr., with an average value of 32 deg. fahr. On idling after the 40-m.p.h. run, the temperature increases range from 27 to 80 deg. fahr., with an average value of 50 deg. fahr. The average values at constant speed do not change appreciably with speed over the range from 20 to 60 m.p.h. On the other hand, the average values on idling change from 43 deg. fahr. after a 20-m.p.h. run to 60 deg. fahr. after a 60-m.p.h. run. Somewhat different average values might

TABLE 2—SUMMARY OF TEMPERATURE DATA AT POINT WHERE VAPOR LOCK OCCURS

| Car | Fuel System | Atmospheric Temperature, Deg. Fahr. | $\Delta T$ Above Atmospheric Temperature, Deg. Fahr. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Constant Speed, M.P.H. | | | Idling, M.P.H. | | |
| | | | 20 | 40 | 60 | 20 | 40 | 60 |
| 1 | MP[a] | 80 | 39 | 35 | 37 | 47 | 43 | 52 |
| 2 | MP | 70 | 28 | 30 | 30 | 54 | 66 | 65 |
| 3 | MP | 85 | 43 | 45 | 52 | 43 | 49 | 61 |
| 4 | MP | 80 | 25 | 25 | 29 | 36 | 41 | 52 |
| 5 | MP | 75 | 30 | 28 | 34 | 45 | 53 | 64 |
| 6 | Vac. | 70 | 32 | 32 | 36 | 48 | 52 | 70 |
| 7 | Vac. | 75 | 38 | 41 | 42 | 49 | 62 | 71 |
| 8 | MP | 80 | 34 | 34 | 35 | 49 | 56 | 63 |
| 9 | MP | 95 | 38 | 40 | .. | 45 | 55 | .. |
| 10 | MP | 75 | 4 | 4 | 10 | 25 | 27 | 47 |
| 11 | MP | 85 | 25 | 28 | 35 | 32 | 39 | 45 |
| 12 | MP | 90 | 38 | 38 | .. | 44 | 54 | .. |
| 13 | MP | 85 | 45 | 40 | 43 | 54 | 60 | 68 |
| 14 | Grav. | 85 | 29 | 26 | .. | 32 | 45 | .. |
| 15 | MP | 85 | 35 | 29 | 29 | 43 | 52 | 64 |
| 16 | Vac. | 90 | 44 | 43 | .. | 60 | 68 | .. |
| 17 | MP | 90 | 42 | 43 | .. | 47 | 60 | .. |
| 18 | MP | 95 | 30 | 32 | .. | 40 | 51 | .. |
| 19 | MP | 90 | 20 | 18 | .. | 25 | 34 | .. |
| 20 | MP | 85 | 24 | 26 | .. | 30 | 37 | .. |
| 21 | MP | 85 | 37 | 37 | .. | 40 | 54 | .. |
| 22 | MP | 85 | 43 | 44 | .. | 61 | 71 | .. |
| 23 | MP | 90 | 28 | 26 | .. | 33 | 41 | .. |
| 24 | MP | 90 | 27 | 27 | .. | 30 | 37 | .. |
| 25 | MP | 70 | 27 | 26 | .. | 43 | 46 | .. |
| 26 | MP | 80 | 24 | 27 | .. | 35 | 40 | .. |
| 27 | MP | 85 | 38 | 38 | .. | 66 | 72 | .. |
| 28 | MP | 80 | 27 | 26 | .. | 35 | 44 | .. |
| 29 | MP | 85 | 30 | 27 | .. | 30 | 32 | .. |
| 30 | MP | 80 | 38 | 37 | .. | 41 | 45 | .. |
| 31 | MP | 75 | 29 | 29 | .. | 48 | 66 | .. |
| 32 | MP | 80 | 28 | 29 | .. | 51 | 59 | .. |
| 33 | MP | 70 | 24 | 24 | .. | 48 | 58 | .. |
| 34 | Grav. | 75 | 44 | 54 | .. | 61 | 80 | .. |
| 35 | MP | 80 | 35 | 36 | .. | 52 | 56 | .. |
| 36 | MP | 75 | 32 | 29 | .. | 32 | 35 | .. |
| 37 | MP | 80 | 39 | 39 | .. | 47 | 54 | .. |
| 38 | MP | 75 | 31 | 32 | .. | 49 | 57 | .. |
| 39 | Vac. | 80 | 31 | 25 | .. | 40 | 39 | .. |
| 40 | MP | 90 | 33 | 33 | .. | 37 | 49 | .. |
| 41 | MP | 85 | 38 | 35 | .. | 54 | 60 | .. |
| 42 | Vac. | 70 | 24 | 24 | .. | 27 | 34 | .. |
| 43 | MP | 80 | 35 | 39 | .. | 35 | 41 | .. |
| 44 | MP | 80 | 29 | 34 | .. | 37 | 48 | .. |
| 45 | MP | 90 | 35 | 38 | .. | 42 | 47 | .. |
| 46 | MP | 85 | 29 | 27 | .. | 29 | 28 | .. |
| 47 | MP | 90 | 41 | 39 | .. | 46 | 50 | .. |
| | AVERAGE | | 33 | 32 | 34 | 43 | 50 | 60 |

[a] MP—Fuel-pump.

TABLE 3—PERCENTAGES OF CARS WITHIN SPECIFIED VAPOR-PRESSURE LIMITS

| Vapor Pressure, Lb. per Sq. In. | Constant Speed of 40 M.P.H. | Idling after 40-M.P.H. Run |
|---|---|---|
| Above 11 | 4 | 0 |
| 10-11 | 32 | 4 |
| 9-10 | 23 | 6 |
| 8-9 | 30 | 19 |
| 7-8 | 9 | 19 |
| 6-7 | 2 | 30 |
| Below 6 | 0 | 22 |

TABLE 4—PERMISSIBLE VAPOR PRESSURE AND CAR PRICE

| Price Class | Number of Cars Tested | Average Permissible Vapor Pressure, Lb. per Sq. In. 40-M.P.H. Constant Speed | Idling after 40-M.P.H. Run |
|---|---|---|---|
| $500-$1,000 | 15 | 9.7 | 7.3 |
| $1,000-$1,500 | 15 | 9.5 | 7.0 |
| $1,500-$2,000 | 8 | 9.5 | 7.3 |
| Above $2,000 | 9 | 9.5 | 7.3 |

be obtained from a speed of 60 m.p.h. if data were available on all of the cars at this speed.

To interpret these data on temperature increases in terms of permissible vapor pressures, the atmospheric temperature must be taken into consideration. Taking 90 deg. fahr. as a typical summer temperature, for purposes of discussion, the permissible Reid vapor pressure corresponding to each average for the 47 cars is 9.5 lb. per sq. in. at constant-speed running, while on idling after runs at 20, 40 and 60 m.p.h. the permissible vapor pressures are 8.0, 7.2 and 6.0 lb. per sq. in. At 80-deg.-fahr. atmospheric temperature, these vapor pressures would be higher by 1.0 to 2.0 lb. per sq. in., while at 100-deg.-fahr. atmospheric temperature the values would be lower by the same amount.

For each of the temperature increases listed in Table 2, the permissible vapor pressures were computed from Equation (1), assuming an atmospheric temperature of 90 deg. fahr. From these vapor-pressure data, the percentages of the cars tested which fell within certain vapor-pressure limits were evaluated and these percentages are shown in Table 3 for 40-m.p.h. constant speed and for idling after a 40-m.p.h. run. It is seen that, for protection against vapor lock on running at 40 m.p.h. in the case of 90 per cent of the cars tested, the vapor pressure would have to be below 8 lb. per sq. in. and this percentage would not change appreciably with car speed. On idling after a 40-m.p.h. run, only 80 per cent of the cars are protected if the vapor pressure is 6 lb. per sq. in., and this percentage changes markedly with the car speed prior to the idling period. Thus, for idling after a 20-m.p.h. run, less than 80 per cent of the cars are protected if the vapor pressure is less than 7 lb. per sq. in., while on idling after a 60-m.p.h. run only about 50 per cent of the cars are protected if the vapor pressure is 6 lb. per sq. in.

These average values are based on the assignment of equal weight to all of the 47 cars, instead of on the basis of the numbers of each car on the road. That the general conclusion would not be materially changed, however, is suggested by the fact that, in 1931 cars, the permissible vapor pressure does not change appreciably with car price. This is illustrated in Table 4, in which the average permissible vapor pressures in each price class are tabulated.

It should be emphasized that these permissible vapor pressures are applicable only to sea-level operation and that the values should be decreased by 1 to 2 lb. per sq. in. for operation between 5000 and 10,000 ft. altitude. Further, the vapor-pressure values under discussion apply to the gasoline in the fuel-feed system and not to the gasoline as it leaves the refinery. Accordingly, these vapor-pressure values can be increased by about 1 lb. per sq. in. on the average to make them applicable to the product as shipped from the refinery and to take care of evaporation losses in handling.

A direct comparison between the results obtained in the present survey and those obtained in 1930 is made in Table 5 in the case of all comparable cars tested in both surveys. The data apply to a constant speed of 40 m.p.h., and the permissible vapor pressures are applicable to an atmospheric temperature of 90 deg. fahr. It is seen that there is little change on the average, although, so far as these cars are concerned, there has been a slight improvement in the 1931 cars. On the other hand, a study of all the data in the two surveys indicates that the average $\triangle T$ of interest is 32 deg. fahr. for the 1931 cars, while, for the 1930 survey, it was 30 deg. fahr. This represents a decrease in permissible vapor pressure on 1931 cars of about 0.3 lb. per sq. in.

On the average it appears, therefore, that there has been no material improvement in 1931 cars. Individual models have been improved considerably while others have become worse. Even where minor improvements in fuel-system design have been made, the general trend toward increasing horsepower has largely offset the improvements. This unchanged situation may be due, in part, to the fact that the results of the 1930 survey were not available in time so that full advantage could be taken of the conclusions in designing the 1931 models.

### Fuel-System Design and Vapor Lock

The general conclusion from the 1931 survey as regards vapor pressures is that reasonable protection for most of the 1931 cars cannot be obtained if they are run on gasolines having a vapor pressure higher than 7 lb. per sq. in. The production of such a product not only limits the supply of suitable gasoline available but introduces considerable difficulty in refinery technique if other properties of the gasoline are to be maintained at a satisfactory level. The problem of eliminating vapor-lock troubles would be greatly simplified in the case of forthcoming models if these cars were equipped with well-designed fuel-feed systems; in fact, such a change in design is the only way of eliminating a large percentage of the vapor-lock troubles. The problem is not very difficult from the design standpoint, and many of the 1931 cars have satisfactory fuel systems.

The contrast between those cars having poorly designed systems and those having well-designed fuel-feed systems is striking, as evidenced by Fig. 3. The lines represent the atmospheric temperatures at which vapor lock would occur, under the conditions specified

TABLE 5—COMPARISON OF RESULTS OF 1930 AND 1931 SURVEYS

| 1931 Survey Car | $\Delta T$ above Atmospheric Temperature, Deg. Fahr. | Permissible Vapor Pressure, Lb. per Sq. In. | 1930 Survey Car | $\Delta T$ above Atmospheric Temperature, Deg. Fahr. | Permissible Vapor Pressure, Lb. per Sq. In. |
|---|---|---|---|---|---|
| 1 | 35 | 9.0 | *A* | 43 | 8.0 |
| 4 | 25 | 10.6 | *R* | 20 | 11.6 |
| 5 | 28 | 10.2 | *H* | 49 | 7.2 |
| 7 | 41 | 8.2 | *C* | 24 | 10.9 |
| 14 | 26 | 10.5 | *G* | 31 | 9.7 |
| 15 | 29 | 10.0 | *P* | 19 | 11.8 |
| 19 | 18 | 12.0 | *B* | 17 | 12.1 |
| 20 | 26 | 10.5 | *L* | 38 | 8.6 |
| 24 | 27 | 10.3 | *J* | 30 | 9.8 |
| 25 | 26 | 10.5 | *M* | 35 | 9.0 |
| 26 | 27 | 10.3 | *N* | 44 | 7.8 |
| 27 | 38 | 8.6 | *Q* | 23 | 11.0 |
| 30 | 37 | 8.8 | *E* | 42 | 8.1 |
| 44 | 34 | 9.2 | *K* | 34 | 9.2 |
| AVERAGE | 30 | 9.9 | | 32 | 9.6 |

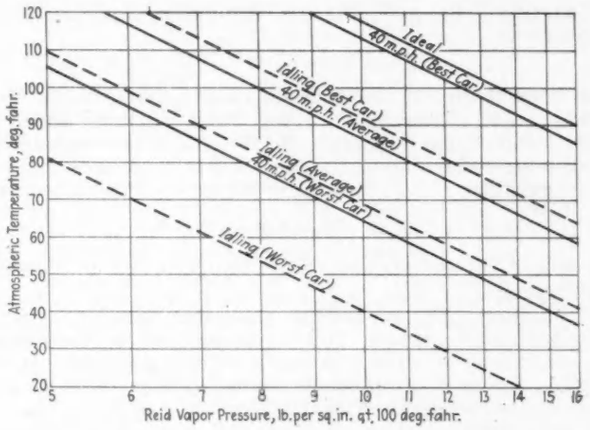



FIG. 3—RELATION BETWEEN PERMISSIBLE REID VAPOR PRESSURE AND ATMOSPHERIC TEMPERATURE

on each line, when using gasolines of various vapor pressures. The ideal line represents a fuel system in which the temperature of the gasoline does not rise above that of the atmosphere. It is the limiting line which can be approached by improvements in fuel-line design but cannot be passed without recourse to refrigeration. The space to the right of each line represents a region in which vapor lock would occur under the conditions specified on the line, while the space to the left represents a region in which vapor lock would not be expected to occur.

Considering an atmospheric temperature of 90 deg. fahr., the vapor pressure must be less than 16 lb. per sq. in. to prevent vapor lock in the ideal fuel system. On the other hand, the vapor pressure must be less than 9.5 lb. per sq. in. when driving at 40 m.p.h., or less than 7 lb. per sq. in. on idling if vapor lock is to be avoided in the average of the cars tested. This difference of 7 to 9 lb. per sq. in. in vapor pressure is indicative of the departure of the average fuel system from the ideal system. While the ideal fuel system probably cannot readily be realized, marked improvement in design unquestionably can be made and it should be possible in every case to reach a point midway between the lines obtained at 40 m.p.h. and on idling with the "Best Car." This would make possible the use of gasolines having vapor pressures between 11 and 15 lb. per sq. in. at 90-deg.-fahr. atmospheric temperature.

An equally interesting comparison can be made between the best car and the worst car tested. At 80-deg.-fahr. atmospheric-temperature, freedom from vapor lock at 40 m.p.h. requires a gasoline having a vapor pressure less than 7.5 lb. per sq. in. with the worst car and less than 17.5 lb. per sq. in. with the best car. On idling after a 40-m.p.h. run, the limits are 5 and 12 lb. per sq. in., respectively. These differences are representative of the extreme variations in fuel-system design and fuel-line temperatures in present-day cars.

As an example of what can be done in the way of improvements in fuel-system design, the data obtained on Cars 10 and 29 will be used as illustrations. The results on the cars are shown in Figs. 4 and 5, respectively. In the case of Car 10, the temperature at the fuel-pump inlet is only slightly above the atmospheric temperature, so at 90 deg. fahr. a gasoline having a vapor pressure as high as 15 lb. per sq. in. could be used when driving at 40 m.p.h. This is made possible by effective installation of the line from the rear tank to the pump, which was so effective in this case that the temperature of the gasoline dropped during passage from the rear tank to the pump inlet. While a drop in temperature is not usual, it has been found in several cases that simple modifications in the installation of the fuel line decreased the fuel temperatures at the pump inlet to such an extent that the permissible vapor pressure was raised approximately 5 lb. per sq. in.

Although the temperatures found with Car 10 at constant speed were low, it is seen that there is considerable difference between the permissible vapor pressures at constant speed and on idling. Material improvement in this respect could be made by changing the position and the method of lubrication of the fuel-pump. This point is illustrated in the case of Car 29, and it is seen from Fig. 5 that there is little difference between the permissible vapor pressures at constant speed and on idling. This is due to the location of the pump, which is driven by a long push-rod off the end of the camshaft, and to the avoidance of circulating hot crankcase-oil through the pump. However, the permissible vapor pressures with this car are far removed from the values for an ideal fuel system; a marked improvement would be possible if a more effective installation were made of the fuel line between the tank and the pump.

The two cars illustrate practical methods of improving the design and installation of fuel-feed systems. A combination of the good features of both designs should produce an almost ideal fuel system in which vapor pressures at least as high as 12 lb. per sq. in. would be permissible, even on idling. While this vapor pressure is probably higher than would be desirable to use in hot weather, such a fuel system would permit almost complete freedom from vapor lock with present-day commercial gasolines.

It is felt that much can be done in the way of simple modifications, such as those mentioned, to keep heat out of the fuel. When this is accomplished, the automotive engineer will have done his part in the solution of the vapor-lock problem.

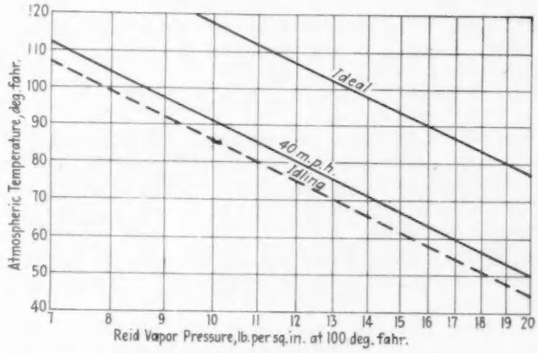



FIG. 4—PERMISSIBLE VAPOR PRESSURES WITH CAR 10

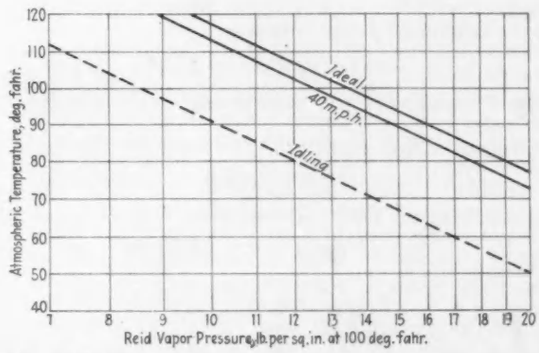



FIG. 5—PERMISSIBLE VAPOR PRESSURES WITH CAR 29

## APPENDIX

### Derivation of Vapor-Lock Equations

In the study of the gas-free vapor pressures of a large number of gasolines and blends, it was found[9] that the vapor pressure changed with temperature according to the relation

$$\log (\pi/14.7) = A\ (1 - \Theta_n/\Theta) \qquad (2)$$

where $\pi$ is the true, or gas-free, vapor pressure in pounds per square inch at 0 deg. fahr. absolute; $\Theta_n$ is the temperature in absolute fahrenheit degrees at which the gasoline starts to boil, namely, the bubble point; $\Theta$ is the temperature in absolute fahrenheit degrees corresponding to the pressure $\pi$; and $A$ is a constant characteristic of the particular gasoline under consideration. The temperature at which any gasoline will start to boil may be obtained by measurement of the vapor pressure at two temperatures by means of Equation (2). However, the measurement of true vapor pressure is an involved procedure, and investigation[9] showed that vapor pressures by the Reid method on all types of fuel gave satisfactory agreement with the gas-free values when the former were multiplied by the factor 1.1 to correct for the larger volume of vapor space employed in the Reid method. Thus

$$\pi = 1.1\ p_R \qquad (3)$$

where $p_R$ is the Reid vapor pressure. Substituting for $\pi$ in Equation (2), there results

$$\log (1.1\ p_R/14.7) = A\ (1 - \Theta_n/\Theta) \qquad (4)$$

Accordingly, determination of the vapor pressure by the Reid method at two temperatures is sufficient for an evaluation of the temperature at which the gasoline starts to boil.

In the case of a large number of gasolines, $A$ was found to vary from 3.3 to 4.5 and had an average value of 4.0. Computation has shown that, for the present purpose, little error is introduced by assuming that $A$ equals 4.0 for commercial gasolines with conventional distillation curves. In this case, measurement of the Reid vapor pressure, at 100 deg. fahr. only, suffices for the evaluation of $\Theta_n$. Accordingly, placing $A = 4.0$ and $\Theta = 560$, Equation (4) becomes

$$\log (1.1\ p_R/14.7) = 4\ (1 - \Theta_n/560) \qquad (5)$$

Although $\Theta_n - 460$ is the temperature in degrees fahrenheit at which the gasoline would start to boil in the fuel-feed system under normal atmospheric pressure, experimental fuel-line work has shown that serious interruption of fuel flow will not occur until the gasoline boils sufficiently to form a volume of vapor approximately equal to that of the liquid gasoline flowing through the lines. Hence Equation (5) must be modified to take this into consideration. It has been found[10] that the change in the vapor pressure, at constant temperature, with increase in the ratio of vapor to liquid volume is given by the relation

$$\triangle\ p_R = -\ 0.025\ p_R\ (V/L) \qquad (6)$$

where $V$ and $L$ are the volumes of vapor and liquid respectively.

Differentiating Equation (5) leads to the relation

$$dp_R/d\Theta_n = -\ 2.3 \times 4\ p_R/560 = -\ 9.2\ p_R/560 \qquad (7)$$

and, considering finite increments, this becomes

$$\triangle\ p_R/p_R = -\ 9.2\ \triangle\ \Theta_n/560 \qquad (8)$$

Equating (6) and (8) to eliminate $\triangle\ p_R/p_R$, there results

$$\triangle\Theta_n = 1.5\ (V/L) \qquad (9)$$

and for $V/L = 1$, to represent conditions of vapor lock, $\triangle\ \Theta_n = 1.5$. Therefore 1.5 deg. fahr. must be added to $(\Theta_n - 460)$ from Equation (5) to obtain the vapor-locking temperature from the Reid vapor pressure. Making this addition and rearranging Equation (5), it becomes

$$t = 259 - 140 \log p_R \qquad (10)$$

where $t$ is the vapor-locking temperature in degrees fahrenheit.

Equation (10) represents a general relation between Reid vapor pressure and vapor-locking temperatures when engine operation at sea level is concerned. It involves the two assumptions; namely, that the gasoline has a conventional distillation curve and that the volume of vapor passing through the fuel line equals the volume of liquid gasoline before vapor lock occurs. The errors involved in these assumptions may be computed from the relation

$$4\ \delta t = (t - 100)\ \delta A + 6.1\ \delta\ (V/L) \qquad (11)$$

where $\delta\ t$ is the variation in the vapor-locking temperature $t$ caused by variations $\delta\ A$ from the value 4.0 assigned to the constant $A$ in Equation (2) and by variations $\delta(V/L)$ from the value unity chosen for the ratio of vapor to liquid volumes when vapor lock occurs.

Consider first only variations in the value of $A$. For gasolines having vapor pressures of 7 and 10 lb. per sq. in., the vapor-locking temperatures $t$ are 141 and 119 deg. fahr., respectively. For $\delta\ A = 0.5$, which is an extreme variation, the errors $\delta\ T$ in the vapor-locking temperatures in these two cases would be 5 and 3 deg. fahr. For more normal variations, $\delta\ A = 0.2$, the respective errors $\delta\ t$ would be 2 and 1 deg. fahr., respectively. Considering next only variations in $V/L$ and assuming that $V/L$ in some cases might be as large as 2.0, then $\delta(V/L)$ is equal to unity and the error caused by assuming $V/L = 1.0$ would be 1.5 deg. fahr. Errors of both types might occur in any individual case and might be additive. However, there is as much chance of them being subtractive as of being additive, so in general the average error from these sources in using Equation (10) should not be greater than 2 deg. fahr.

Although Equation (10) is limited to conditions of sea-level operation, an analogous general equation can be deduced in a similar manner, which will be applicable to any altitude. This equation is:

$$t = 95.7 - 140 \log (p_R/p) \qquad (12)$$

where $p$ is the barometric pressure at any altitude. If it is desired to know the vapor pressure permissible at any altitude $A$, when the permissible vapor pressure at sea level is known, for the same vapor-locking temperature in the two cases, a simple relation can be deduced from Equation (12). Designating the permissible vapor pressure at sea level by $p_R$ and at any altitude by $p_{R_1}$, then, since $t$ is the same in both cases, it follows that

$$p_{R_1} = p_R\ (p/14.7) \qquad (13)$$

For normal conditions, the value of the barometric pressure $p$ may be obtained from the United States Standard Atmosphere table or chart[12]. Thus, at 10,000 ft., $p = 525$ mm. of mercury or 10.16 lb. per sq. in. In this case $p_{R_1} = 0.691\ p_R$.

An approximate rule, which is sufficiently accurate for most purposes, can be expressed by means of the relation

$$p_{R_1} = (1 - 0.032\ A)\ p_R \qquad (14)$$

where $A$ is the altitude in thousands of feet.

---

[9] See S.A.E. JOURNAL, July, 1930, p. 93.

[10] See S.A.E. JOURNAL, July, 1930, p. 93.

[11] See S.A.E. JOURNAL, July, 1930, p. 93.

[12] See Bureau of Standards Miscellaneous Publications No. 82; see also S.A.E. JOURNAL, August, 1930, p. 217.

## THE DISCUSSION

A. E. BECKER[13]:—Of the four factors mentioned by the authors as affecting vapor lock, namely, vapor pressure of gasoline, design of fuel-feed system, atmospheric temperature and altitude, only the first two factors are subject to control. The refiner is responsible for maintaining the vapor pressure of his gasoline at a figure which will give reasonable freedom from vapor-lock difficulties in cars on the road under all operating conditions encountered in both summer and winter, either at sea level or in the mountains. Unfortunately, he has no control over the design factor and must rely upon the automotive design engineer "to keep heat out of the fuel system."

With the development of cracking processes the quality of gasolines, particularly as regards volatility and antiknock quality, was considerably improved. Full utilization of these good qualities requires that cars be designed so that the increased volatility will not cause vapor-lock difficulties. Careful study of the present paper and the work that has preceded it will show that the desired improvement can be obtained by fairly simple design changes.

The authors' conclusion that the Reid vapor pressure (the 10-per-cent-evaporated point on the A.S.T.M. distillation curve is equally significant) determines essentially the maximum permissible fuel temperature in the feed system without encountering vapor lock agrees with the conclusions drawn as a result of similar work[14] in the Standard Oil Development Co.'s laboratories. Obviously, the maxima temperatures existing in the fuel-feed systems of the worst vapor-locking cars on the road under the atmospheric temperatures and altitudes at which they are operated determine the permissible volatility of the refiner's gasolines. Otherwise he would be compelled to market additional gasolines, with a consequent increase of facilities for storage, transportation and marketing. Such a solution would be undesirable to the refiner, nor would the necessity of having the customer ask for gasoline specially produced to prevent vapor lock in his cars be pleasing to the motor-car manufacturer.

The limitations imposed on the refiner at present are made clearly evident by comparing the temperature data for Car 10 with those for Car 34 or by comparing the idling line for the best car with that for the worst car in Fig. 3. It will be seen that a Reid vapor pressure of about 4 or 5 lb. per sq. in. at 100 deg. fahr. would be required to give satisfactory operation in the worst car tested when operating at sea level on a warm summer day with the thermometer at 90 deg. fahr. On the other hand, the best car tested would be free from vapor-lock trouble under the same operating conditions with a gasoline having a Reid vapor pressure of 10 lb. per sq. in. Even in the latter case the permissible vapor pressure probably could be raised to 13 or 14 lb. by a few simple changes in design, as pointed out by the authors.

However, the refiner has no choice; he is obliged to market a gasoline of very low volatility to give reasonably good service in Car 34. This unnecessarily penalizes Car 10, since a more volatile fuel would assure easier starting during the spring and autumn months, would result in smoother acceleration and performance, and in general would be of better antiknock quality. This is particularly regrettable since the authors found that such a simple expedient as transferring the fuel line between the rear tank and the pump to the outside of the frame channel was sufficient to very considerably reduce the heat accumulation in the fuel-feed system in the two cars so altered.

The design engineer is interested in keeping the fuel-feed lines where there is least danger of breaking them by a collision. He probably will find that the decreased temperatures obtained by moving the fuel lines to the outside of the frame channel can be largely accomplished by merely moving the fuel line to the inside of the other frame channel; that is, as far from the exhaust pipes and muffler as possible. Clearly, the automotive engineer should act to keep heat out of the fuel system. Meanwhile, refiners must set the 10-per-cent points of their gasolines high enough or the Reid vapor pressures low enough to assure good operation in the great majority of cars now on the road.

### Easy Starting and Anti-Vapor-Locking Require Opposed Gasoline Properties

J. BENNETT HILL[15]:—Dr. Bridgeman's paper has pointed out very plainly that avoidance of vapor lock is a problem of automobile design. I recall the surprise of a few of our leading automotive engineers a year ago when it was stated to them that the gasoline refiner was ready and anxious to produce an easier-starting gasoline but was stopped from doing so by the vapor-locking delinquencies of some of our cars on the road. That, however, is exactly the situation, but it goes even further than that.

Dr. Bridgeman has shown that the quality of gasoline which makes for easy starting, namely, the 10-per-cent point or the Reid vapor pressure, also makes for vapor lock. The data he has presented show that it is impossible to produce a gasoline which, during the spring and autumn, will start a car satisfactorily in the cool of the morning and operate it in the heat of the day without vapor lock, if the car is one of the vapor-lock offenders. A few figures will clearly illustrate this.

The "worst-car" idling curve of Fig. 3 and a satisfactory starting curve on the same coordinates leave an area between the two in which the performance is wholly satisfactory. By "satisfactory" starting I mean something better than the "easy" starting figure used in some of the previous papers from the Bureau of Standards. The easy starting figures are based on a start within 10 to 11 revolutions, but the public would criticise a gasoline severely if that were the best it could do. Drivers generally insist on starting within one to two revolutions. To be conservative, the following figures have been based on four revolutions as satisfactory starting.

If we select at random from the Weather Bureau data those for Pittsburgh for the month of April, 1931, computation shows that the optimum gasoline for Dr. Bridgeman's worst car, considering both starting and vapor lock, would have a Reid vapor pressure of 6½ lb. Such a gasoline would start the engine satisfactorily at 38 deg. fahr. and would vapor-lock in this car at an atmospheric temperature of 65 deg. fahr. The Weather Bureau data show, however, that in Pittsburgh in this one month there were 14 days in which the temperature fell below 38 deg. and 12 days in which it rose above 65 deg. fahr., in the shade. Making the obviously ridiculous assumption that the gasoline refiner could know in advance the temperatures that would be encountered during each month and that he could change his gasoline each month to fit these conditions, it would still be impossible for him to sell a gasoline that would not be open to complaint as regards starting or vapor lock, or both. On the other hand, if all cars were even as good as Dr. Bridgeman's best car,

[13] M.S.A.E.—Standard Oil Development Co., New York City.

[14] See S.A.E. JOURNAL, June, 1930, p. 736.

[15] M.S.A.E.—Chief chemist, Atlantic Refining Co., Philadelphia.

and we have no reason to believe that that is the best that can be done, a gasoline could have been supplied for the month which would have given satisfactory starting and vapor-lock performance on every day in the month and left considerable margin for more unusual days. With information such as Dr. Bridgeman has presented, the time is at hand when the burden of vapor-lock complaints will be shifted from the gasoline to the car and when the prospective automobile purchaser will ask the automobile dealer the question, "Does you car vapor-lock?"

### Refiners Doing All They Can

G. G. OBERFELL[16]:—From a technical viewpoint the statement can safely be made that the problem of vapor lock has been solved. We now know what it is, what causes it and how it can be avoided. However, from an economic viewpoint, it is far from being solved. It is believed that the automotive engineer does not fully realize that he alone holds the key to the solution of this latter phase of the problem, which is the most important one. Since a fuel with too high a vapor pressure will have unsatisfactory starting qualities, the fact is evident that the design of the fuel system of the automobile must take into consideration these two opposing and very important factors.

The propane, butane and pentane fractions of motor fuel are the only ones that need to be given practical consideration so far as vapor-locking difficulties are concerned, since they contain the only compounds having vapor pressures high enough to cause such troubles. The motor-fuel manufacturer has realized for several years that the presence of propane in gasoline was an economic waste, the reason being that, for a given vapor-pressure specification, three or four volumes of butane could be added for each volume of propane removed from the gasoline. Therefore, to include propane meant a reduction in the yield of gasoline. The motor-fuel manufacturer has also known for many years that the total quanity of available pentane could be incorporated in the fuel without raising the vapor pressure of his finished product beyond the safe limit for satisfactory engine performance. This means that, to the motor-fuel manufacturer, the problem resolves itself into a consideration of butane alone, since economic conditions demand the elimination of propane and since the available supply of pentane is not sufficient to cause trouble. The benefits to be gained by increasing the butane content of motor fuel are (*a*) improved ease of starting, (*b*) acceleration and warming-up characteristics, (*c*) better antiknock rating and (*d*) an economical increase in the gasoline supply. Table 6 shows the estimated properties of the propane, butane and pentane fractions of motor fuel.

[16] Director of research, Phillips Petroleum Co., Bartlesville, Okla.

TABLE 6—PROPERTIES OF THE VOLATILE FRACTIONS OF MOTOR FUEL

| Fraction | Specific Gravity | Theoretical Vapor Pressure at 100 Deg. Fahr., Lb. per Sq. In. Abs. | Increase in Reid Vapor Pressure Due to Presence of 1 Per Cent by Volume, Lb. per Sq. In. at 100 Deg. Fahr. | Percentage Present in Average Motor Fuel, by Volume | Lowest Easy-Starting Temperature, Deg. Fahr. | Octane Number | Percentage That Can Be Included in Motor Fuel of 12-Lb.-per-Sq.-In. Reid Vapor Pressure if Fractions More Volatile are Absent |
|---|---|---|---|---|---|---|---|
| Propone | 0.509 | 187.0 | 2.46 | 0.3 | —137 | Considerably better than iso-octane | ... |
| Iso-butane | 0.564 | 73.9 | ... | ... | —100 | 100 | ... |
| N-butane | 0.584 | 52.4 | ... | ... | — 82 | 90 | ... |
| "Butanes" | 0.581 | 55.7 | 0.6 | 4.7 | — 90 | 93 | 14.2 |
| Iso-pentane | 0.625 | 20.4 | ... | ... | — 49 | 91 | ... |
| N-pentane | 0.631 | 15.6 | ... | ... | — 37 | 64 | ... |
| "Pentanes" | 0.628 | 16.5 | 0.13 | 9.4 | — 45 | 74 | 51 |
| N-hexane | 0.663 | 4.9 | Negligible | ... | + 7 | 35 (Est.) | 100 |
| "Hexanes" | 0.669 | 8.3 | " | 12.1 | — 20 | 63 | 100 |
| N-heptane | 0.688 | 1.6 | " | ... | + 44 | 0 | 100 |
| "Heptanes" | 0.724 | 2.9 | " | 13.0 | + 22 | 65 | 100 |

TABLE 7—EFFECT OF BUTANE UPON PERFORMANCE CHARACTERISTICS OF GASOLINE

| Butanes Content, per cent by volume | 0 | 5 | 10 | 15 | 20 |
|---|---|---|---|---|---|
| Reid Vapor Pressure, lb. per sq. in. at 100 deg. fahr. | 3.3 | 7.3 | 11.0 | 14.5 | 17.8 |
| Vapor Lock Temperature, deg. fahr. | 237 | 197 | 159 | 124 | 92 |
| Lowest Atmospheric Temperature Giving Easy Starting, deg. fahr. | +50 | +30 | +3 | —30 | —50 |
| Lowest Atmospheric Temperature Giving Satisfactory Acceleration with Choke, deg. fahr. | 85 | 75 | 68 | 60 | 52 |
| Octane Number | 55 | 57 | 59 | 61 | 63 |

Highly heated automobile fuel-systems, which are the relics of by-gone days, require gasoline of such low vapor pressure to prevent vapor lock that easy starting in cold weather is an impossibility. In this connection a comparison is made in Table 7 of the properties of the butane-free-base product of the petroleum industry with the same product to which various quantities of butane have been added. Ten to 15 years ago, when motor fuels were much less volatile than now, easy-starting gasoline was very difficult to obtain. Today the most loyal car purchaser will not endure with patience poor starting characteristics in either car or gasoline. Table 7 brings out forcefully the fact that the ability to start the engine in cold weather depends solely upon the butane supply of the petroleum industry.

### Butane the Crux of the Situation

Most of the increased vapor pressure of commercial gasoline of recent years has resulted from the increased use of cracking processes. Many refineries have installed efficient vapor-recovery and stabilizing units, so that the maximum permissible quantity of butane can be saved while discarding propane to be used for other purposes. Under these circumstances the refiners find themselves with a surplus of butane, which in existing automotive fuel systems cannot be included in the motor fuel. I estimate that, on the average, refiners have available sufficient butane to include about 9 per cent in their finished gasoline without using any butane derived from the natural-gasoline industry. The natural gasoline that is blended with the refinery gasoline would add about 3 per cent, which would make a total of 12 per cent in the final product. This does not represent the entire potential supply, since additional quantities of butane can be extracted from the gas in the natural-gasoline industry when economic conditions justify such a procedure.

It is estimated, as seen in Table 8, that about 4,000,000 gal. of butane is today being wasted or put into inferior use such as firing stills or boilers at refineries and natural-gasoline plants. The potential supply of the entire industry which is not being used is more than 6,000,000 gal. per day. If automotive fuel systems were suitably designed, the former quantity could be included in the finished motor fuel. This means that the supply of motor fuel could be increased greatly by the simple and cheap expedient of changing the "plumbing" of the automobile fuel lines. The additional volume of butane that can be marketed in gasoline if the fuel systems of the automobile are better designed does not represent the entire increase in gasoline that would result, as not only is the volume increased but the quality of the gasoline is improved. For the same quality, as judged by volatility, the increase in production would

be approximately twice that represented by the amount of butane that could be added.

Table 9 gives for the years 1920, 1925 and 1930 the proportions of the motor fuel supplied by the straight-run, the cracking and the natural-gasoline recovery processes. Table 10 shows the estimated composition and vapor pressures of motor fuel marketed in the same years. These two tables represent estimates based upon information obtained from reports of the Bureau of Mines.

The first three columns of Table 11 show Dr. Bridgeman's maximum permissible vapor pressures for "average" cars and the "best" car, and the last three columns show the butane content that is possible under the temperature conditions given in the first column. By improving the fuel systems from the "average" condition to the "best" condition, all of the available butane could be used, even in the hot summer months. How critical this condition is becomes evident when the fact is considered that, with "average" cars, the maximum available quantity of butane cannot be used unless the fuel is to be used at atmospheric temperatures below 60 deg. fahr. On the other hand, with the "best" car, all the available butane can be used at temperatures lower than 90 deg. fahr.

The only way in which the petroleum industry can cooperate to eliminate vapor lock is to market gasolines having vapor pressures low enough to give satisfactory performance under the conditions imposed by nature and by the automotive engineer. Although vapor lock has occasionally been encountered with some gasolines on the market, and some makes of car will vapor lock under hot summer operating conditions with almost all gasolines, vapor-lock experiences are comparatively rare. The gasoline marketer cannot afford to sell a motor fuel that is unsatisfactory in this respect, as it would not be favorably received and he would be unable to retain his business.

Evidently, then, the motor-fuel manufacturer has done all he can do with the vapor-lock problem. His contribution has been to throw away the portion of his product that is most valuable and upon which practically all the motor-fuel manufacturing costs have been expended. The butane fraction, which is the cream of the motor fuel, is to a large extent being forced into the low-grade fuel market in competition with coal, coke and gas oil.

### Ideal Fuel Line Would Make Possible One Year-Round-Fuel Specification

A. LUDLOW CLAYDEN[17]:—If the data presented by Mr. Oberfell are studied, it will be seen that, if one gasoline is made which will be satisfactory for the worst car in Dr. Bridgeman's analysis as regards the vapor-locking, and another gasoline is made which will be satisfactory on vapor lock for the best car, that second gasoline will give the same degree of starting at 0 deg. fahr. as the other one will give between 50 and 60 deg. fahr. This is an enormously important difference.

Another fact that some men in the automobile industry do not seem to appreciate is that vapor lock is not entirely a summer problem. The figures given by Dr. Bridgeman are based on degrees above atmospheric temperature, but it by no means necessarily follows that those relationships hold true for any atmospheric temperature. At an atmospheric temperature of, say, 70 deg., the rise in the particular fuel system might be 40 deg. above that temperature; but, if the atmosphere were zero, the rise might be considerably more than 40 deg. above zero. Since the temperature of the power-plant as a whole does not vary much between summer and winter under normal operation, and the high temperature in some of the fuel lines is caused by proximity to the engine, the variations between summer and winter fuel-line maxima will not be nearly so great as the variations between summer and winter atmospheric temperatures.

The established practice of the industry has been to change gasoline specifications two or three times a year to anticipate probable weather changes, but however careful a refiner is, he cannot possibly guarantee that the change will be made in any particular service station at any particular time. Still less can he guarantee that the weather will be in accordance with expectations or the predictions of the Weather Bureau. It will average so over the entire Country, but always in some part of the Country a departure from the average will be rather large.

A few years ago strong economic reasons existed for the petroleum industry to wish to put out gasoline of the lowest possible volatility. Consequently, as soon as the winter was over, refiners would say, "Thank goodness, we don't have to buy any more of that natural gasoline." Today this is not the case. I believe that almost any refiner in the industry would much rather make practically the same gasoline all the year round and avoid the trouble that arises from having two or three specifications. This can be done if the "average" cars can be made as good as regards vapor lock as the best example found by Dr. Bridgeman.

When it is remembered that not one of this representative group of cars was designed with any partic-

[17] M.S.A.E.—Research engineer, Sun Oil Co., Philadelphia.

TABLE 8—BUTANE SUPPLY AND ITS EFFECT UPON THE VAPOR PRESSURE OF MOTOR FUEL

| Butane Content, Per Cent | Reid Vapor Pressure, Lb. Per Sq. In. | Estimated Daily Waste of Butane at Refineries and Natural-Gasoline Plants, Gal. |
|---|---|---|
| 0 | 3.3 | 7,000,000 |
| 2 | 4.9 | 5,900,000 |
| 4 | 6.5 | 4,800,000 |
| 6 | 8.0 | 3,700,000 |
| 8 | 9.5 | 2,600,000 |
| 10 | 11.0 | 1,500,000 |
| 12 | 12.4 | 400,000 |

TABLE 9—SOURCES OF MOTOR FUELS, IN PERCENTAGE OF TOTAL

| Year | Straight Run | Cracked | Natural |
|---|---|---|---|
| 1920 | 78.9 | 13.6 | 7.5 |
| 1925 | 66.1 | 24.0 | 9.9 |
| 1930 | 51.1 | 37.2 | 11.7 |

TABLE 10—ESTIMATED COMPOSITION AND VAPOR PRESSURE OF MOTOR FUELS

| Year | Estimated Butanes and Lighter Fractions, Per Cent | Estimated Pentanes and Lighter Fractions, Per Cent | Estimated Reid Vapor Pressure, Lb. per Sq. In. |
|---|---|---|---|
| | *Winter Fuels* | | |
| 1920 | 3.7 | 10.6 | 6.2 |
| 1925 | 5.4 | 12.8 | 8.3 |
| 1930 | 6.7 | 16.5 | 10.0 |
| | *Summer Fuels* | | |
| 1920 | 3.1 | 8.6 | 5.2 |
| 1925 | 4.5 | 11.2 | 7.1 |
| 1930 | 5.3 | 14.3 | 8.4 |

TABLE 11—DR. BRIDGEMAN'S VAPOR-PRESSURE LIMITS IN TERMS OF BUTANE INCLUSION AND MOTOR-FUEL SUPPLY

| Atmospheric Temperature, Deg. Fahr. | Maximum Reid Vapor Pressure, Lb. per Sq. In. | | Butane Content of Motor Fuels, Per Cent | | Increase in Motor Fuel Supply, Per Cent |
|---|---|---|---|---|---|
| | "Average" Cars | "Best" Car | "Average" Cars | "Best" Car | |
| 100 | 6.7 | 11.4 | 4.4 | 10.6 | 7.2 |
| 90 | 7.9 | 13.4 | 5.9 | 13.4 | 8.7 |
| 80 | 9.4 | 15.9 | 7.8 | 17.1 | 11.3 |
| 70 | 11.0 | 18.7 | 10.0 | 21.5 | 14.7 |
| 60 | 13.0 | 22.0 | 12.8 | 28.5 | 22.0 |

ular thought given to fuel-line temperature, the designer should not be satisfied if he can merely make his car as good as the present "best"; he should be able to improve on that. I see no reason why the "ideal" line shown by Dr. Bridgeman should not be very closely approached. If that is done, very much easier starting inevitably will result.

At present the tendency of the automobile industry is to blame all the starting difficulties on lubrication. Granting that the viscosity of the lubricant is a very important factor, it must be remembered that it is a far more difficult characteristic to control, either in the automobile or in refining, than is the volatility of gasoline. As I understand the work done by the Bureau of Standards and several times reported to this Society, the ease of starting does not depend upon the actual speed of cranking, but upon the quantity of gasoline that can be pumped into the engine and the volatility of the gasoline. That being so, and assuming that the engine cannot be turned over very fast, one can be fairly sure of getting a satisfactory start if the fuel is highly volatile; that is, if it contains a large percentage of low-boiling-point material. On the contrary, if the fuel lacks a large proportion of volatile material, many more engine revolutions will be needed, or, as it is ordinarily expressed, a much higher cranking speed will be required to obtain as prompt a start. I feel that the petroleum industry responded very well indeed to the demand for better antiknock quality in gasolines; I think it has responded rather well to the demand for lower vapor pressures; but I know that if something is not done in fuel-line design we shall have alternate demands for lower vapor pressures in the summer and easier starting in the winter.

### Fuels, Not Cars, Have Changed

E. S. MARKS[18]:—In the recent past we were required to apply more heat to the fuel systems; now we are called upon to remove that heat. It goes without saying that we are very anxious to have these tests made on our cars by the Bureau of Standards and to do everything we can to lower the fuel-line temperatures, because we think it is a good thing to do. However, that certainly will not take care of the difficulties we seemingly are running into now more than we ever did before. That fact indicates to us that some change has occurred in the petroleum industry. We do not presume to know what it is, but we do know that we are having an increasing amount of vapor-lock troubles with cars on the road which are of exactly the same design as they were four or five years ago.

CHAIRMAN A. L. BEALL[19]:—At present the petroleum industry knows something about the operating characteristics of its product. We have learned something about the necessary values to provide good starting and to eliminate the trouble from vapor lock, and our knowledge of these came at about the same time. After improving the fuels to volatilities at which we could provide reasonable starting for the climate, we began to get vapor-locking troubles.

F. C. MOCK[20]:—I remember definitely that vapor lock began to become acute just about the time that the oil companies started putting natural-gas light-ends into the gasoline. But I think that the automotive industry has been somewhat delinquent, in that it has always been reluctant to recognize, measure and deal with these effects of temperature extremes upon the fuel and intake systems.

Preheating the gasoline in the line is entirely unnecessary as an aid to vaporization, and bringing these fuel-line temperatures down should neither increase nor decrease the need of heat application to the mixture.

### Why Gasoline Properties Have Been Changed

MR. CLAYDEN:—Mr. Marks raised a question which very definitely should be answered. That is that the trouble from vapor lock is recent. It is recent for two reasons: one is the popularity of the fuel-pump, which eliminates the weathering that used to take place in the vacuum tank; the other is that gasolines are more volatile than formerly. They have been made so in response to an unmistakable demand for easier starting, not only in winter but in summer; more rapid warming up with less use of the choke and for better acceleration. The public demand is the fundamental reason for the change in gasolines. The public really wants those advantages and, between us, we generally contrive to give the public what it demands. This is a job which must be accomplished through the cooperation of both industries.

Admitted that one-half of the cars running today cannot be altered, the petroleum industry must furnish fuels for some time to come with very definite restrictions upon them, but the longer the design changes are delayed, the longer that condition of affairs will have to persist. The oil industry's reason for placing such great emphasis on the situation today, I think, is because there is such a great time lag before any change in automotive design influences the general situation.

DR. H. C. DICKINSON[21]:—One minor point has not been mentioned. Obviously, a comparatively small percentage of the 25,000,000 cars on the road are fitted with fuel-pumps, and none of those fitted with vacuum or gravity systems has given trouble to any great extent. So there is more weight than might appear at first in the demand that correction be made as promptly as possible. Only those cars having fuel-pumps are likely to give trouble.

CHAIRMAN BEALL:—The automobile industry has for years criticized the petroleum industry for being slow. We have a little momentum now, and as we learn we endeavor to improve our production. The Cooperative Fuel-Research Committee's work has given us the information on which we made what Mr. Clayden suggested was a profitable change in improving starting characteristics. Now vapor-lock trouble seems to be coming along with it; but that is a problem the oil industry can solve only in part. A good deal of evidence has been presented at this meeting to indicate what can be done by the automotive designer. If the data on the cars that Dr. Bridgeman has checked for temperatures in 1931 are indicative of the 1931 models, not a great deal of progress has been made since last year; we hope for more progress next year.

### Vapor Pressure of 12 Lb. Seems Desirable

D. P. BARNARD, 4TH[22]:—Mr. Oberfell showed that iso-butane, in the quantity in which it is available, would raise the Reid vapor pressure probably to 12 lb. per sq. in. Iso-butane has a knock rating of about 100 octane number, and normal butane about 90 octane number. Therefore there are good reasons for including all the butane possible in the gasoline to produce a high antiknock-rating fuel as well as one that will give good starting and acceleration.

A slightly different angle to the subject is that there is now a rather general tendency to use ethyl gasolines, and the butanes, particularly iso-butane, respond very nicely to the addition of lead. Therefore much higher knock-rating gasolines can be made by using all the

[18] M.S.A.E.—Chief engineer, H. H. Franklin Mfg. Co., Syracuse, N. Y.

[19] M.S.A.E.—Engineer, refined oil department, Vacuum Oil Co., New York City.

[20] M.S.A.E.—Engineer, Bendix Research Corp., East Orange, N. J.

[21] M.S.A.E.—Chief, heat and power division, Bureau of Standards, City of Washington.

[22] M.S.A.E.—Research engineer, Standard Oil Co., (Indiana), Whiting, Ind.

iso-butanes possible and continuing the use of lead tetraethyl.

Another point is that gasolines which are quite well stabilized, so as to get in the maximum amount of those constituents, probably vapor-lock somewhat more readily than the Reid vapor pressures would indicate. The best data we have accumulated so far, and which are quite tentative, indicate that a gasoline having a very flat distillation curve in the first 25 or 30 per cent may vapor-lock at Reid pressure 1 lb. per sq. in. lower than a normal gasoline which would have double the slope at the 10-per-cent point. The difference in temperature is about 10 deg. fahr. in several cases that have been observed. From the oil man's viewpoint, a 12-lb.-per-sq.-in. Reid pressure looks like a rather convenient goal to work toward at present. The problems of handling losses become acute with gasolines of more than 12-lb.-per-sq.-in. Reid vapor pressure. The oil industry in general probably would not be interested in trying to establish gasolines of higher vapor pressures, but the figure of 12 lb. per sq. in. looks very attractive at present.

MR. OBERFELL:—If I understood Mr. Barnard correctly, he inferred that the addition of butane would cause a gasoline to vapor-lock more readily than the gasoline without so much butane and with the same vapor pressure. A point that I tried to make was that, as we are using all the rest of the products that are heavier than butane, the pentanes and hexanes, nothing is left for us to do but to add the butane. It is true that a gasoline having a flat distillation curve for the same vapor pressure will cause vapor-locking more readily than one having a steep distillation curve. The only way to get that flat curve is with prodigious quantities of natural gasoline that contains plenty of pentanes and hexanes.

### Fuels Marketed from Montana to Nevada

J. M. EVANS[23]:—Our experience on the Pacific Coast may be of some interest, because we market in a territory from Montana to Arizona and west to the coast, this area having wide temperature differences. We have studied the Weather Bureau charts throughout the marketing territory and found that it was necessary to market three or four different types of gasoline controlled by the 10-per-cent-evaporated point or the vapor pressure. By changing each of these about four times a year, we have been able to give easier starting and to eliminate much of the complaint on vapor lock. We keep those different gasolines on hand at our two refineries, one of which ships to the South and one to the North. By studying our average maximum and minimum temperatures and supplying gasolines controlled for the average car, not the worst car, and for the average temperature, we are able to meet satisfactorily all conditions encountered in the various districts of our marketing territory at any given season.

### Vapor Pressures Have Not Increased

DR. O. C. BRIDGEMAN:—To answer Mr. Marks, I think there are two reasons why more complaints about vapor lock have been received in the last few years than formerly. The first, and very important, one is that the public is beginning to know what vapor lock is. All kinds of car drivers will say that they are having certain kinds of trouble with their cars but that it is not vapor lock. When they have answered a few questions that are asked, the fact becomes obvious that they are having vapor lock and do not know it. However, drivers are becoming more and more conscious of the fact that their trouble has actually been vapor lock. The second reason for complaints is, I believe, that fuel-pumps are more responsible for vapor lock than any other one thing. The increasing introduction of fuel-pumps and fuel-feed systems has greatly aggravated the amount of vapor-lock trouble.

Mr. Clayden's remarks about the increase of volatility of motor fuel may be true but that increase does not imply that the vapor pressure increases. Volatility and vapor pressure are two independent things, if the gasoline contains propane, as most motor gasolines do. The surveys of the Bureau of Mines have shown that the vapor pressures of gasolines have not increased much in the last few years; we know that in the summer they have been decreasing, due largely to better stabilization. I am sure that the vapor pressure of the gasoline cannot be blamed for the increasing amount of vapor lock.

I should say that the average vapor-locking temperature in the summer is around 130 or 135 deg. fahr., and that the maximum may be around 145 and the minimum around 120 deg. fahr.

### Crankcase Temperature also Affects Fuel System

One other point, not mentioned in the paper, is that, while the heating of the fuel-feed systems can be blamed for a large amount of vapor-lock trouble, excessively high crankcase temperatures are contributory to the high fuel-line temperatures. We have a case this year of one car in which the fuel-feed system is not by any means ideal, although not nearly so bad as some that we have seen, yet the gasoline temperature at the fuel-pump outlet ran more than 100 deg. above atmospheric temperature. We considered that we had designed the resistance thermometers so that the readings would stay on the scale, but for a while we thought that the temperature of this car was going to run off the scale. That, apparently, was a case of heat transmission from the extremely hot crankcase.

CHAIRMAN BEALL:—Would you care to hazard an estimate as to the lowest and highest vapor pressures in the current gasolines?

DR. BRIDGEMAN:—In the summer around the Atlantic Seaboard, as far as my information goes, not many gasolines have a vapor pressure higher than 8 lb. per sq. in. In the Middle West they may run somewhat higher, possibly around 9 or 10 lb. per sq. in. Last year there was a curious anomaly in that the farther south one went the higher was the vapor pressure. That situation is being taken care of all right now, I believe, so that probably no more vapor-lock troubles occur in one part of the Country than in other parts.

T. A. BOYD[24]:—A few days ago I was looking up the vapor pressures of summer gasolines as given in the 1930 survey of the Bureau of Mines (R. I. 3063). A Reid vapor pressure of 10 lb. per sq. in. was the highest, and the lowest was somewhat less than 5 lb. per sq. in., the average having been about 7 lb. per sq. in.

[23] Manager, sales engineering and development, Associated Oil Co., San Francisco.

[24] M.S.A.E.—Head of fuel section, General Motors Corp., Research Laboratories, Detroit.

# Practical Experiences with Devices for Damping Torsional Vibrations

Semi-Annual Meeting Paper

By Erich Sandner[1] and J. Barraja-Frauenfelder[2]

EARLY troubles experienced with torsional vibration in the shafting of marine and Diesel engines are mentioned, following which the various types of torsional-vibration damper are listed. Comments on the different ones are presented with particular reference to a damper with hydraulic coupling for a 3000-hp. 10-cylinder Diesel engine.

The operation of this damper is described at some length, the text being supplemented by illustrations. Results of tests with this device are presented graphically, and the conclusion is drawn that the damping flywheel with hydrostatic coupling permits (*a*) damping of vibration of shafting even when running in the most dangerous speed-ranges of the largest engines and (*b*) running at all speeds without regard to vibration and without resorting to hand operation of the damping device.

One of the written discussions submitted is a critical review of the vibration-damping problem, the principal points being that the Lanchester type is both cheap and efficient and that performance variations can be completely eliminated by lubricating the friction plates. Such procedure would require heavier loading springs due to a lowered coefficient of friction. In the other written discussion, damping vibration is said to be merely a question of energy dissipation and emphasis is laid on the point that the design of a vibration damper should be such that no auxiliary devices are required to assure its satisfactory operation.

GENERAL familiarity on the part of the reader with the origin and nature of torsional vibrations is assumed in this paper. This subject has been widely written about and discussed in the last few years in a long series of articles, lectures and publications. We may mention the articles by Frank M. Lewis, professor of mathematics, Webb Institute of Naval Architecture, and the paper on the Range and Severity of Torsional Vibrations in Diesel Engines[3], by Frederic P. Porter, as outstanding American contributions.

The first experiences with torsional vibrations in shafting date back about 30 years, and in the main concern large reciprocating marine installations in which various unexplainable ruptures appeared. Even then, breakdowns were recognized as being due to synchronous vibrations, and the origin of, and the results consequent upon, such vibrations were correctly interpreted. Because these casualties occurred in isolated cases only, the engineering profession at large did not pay much attention to these phenomena and for many years nothing of importance was heard.

### Early Troubles with Torsional Vibration

Shortly before the War, when the use of larger high-speed Diesel engines in submarine vessels compelled the designers to look into these vibrations in lineshafting and when they caused many expensive service interruptions with consequent costly repairs, the necessity of investigating the vibrations analytically and experimentally manifested itself forcibly. However, up to a few years ago these fractures occurred more often in high-speed Diesel engines. Originally the cause was conveniently assigned to faulty material or to lightness of design. As a matter of fact, these disturbances might have been avoided by proper calculations beforehand. Another reason was that, up to a short time ago, only a few outstanding specialists were able to understand the whole complex subject of synchronous vibrations and to make the necessary calculations. The methods of calculation, however, were not, at that time, reduced to the simplified formulas demanded by the practical engineer and designer of today.

When these severe and frequent interruptions occurred in connection with high-speed Diesel engines, little information was available to the public because in most cases the casualties occurred in naval vessels. Navies, as is well known, in such cases always endeavor to cover everything with a cloak of secrecy, to the great detriment of technical progress. A commendable exception is the American Navy, which publishes most of this information, without doubt to its own benefit and that of the engineering profession.

Torsional vibrations are likely to occur in all high-speed multicylinder internal-combustion engines, and for such plants the range of the critical vibrations must be calculated and the shafting designed accordingly. If the case considered is an engine with a fixed speed, or with a very limited range of speed, the elastic character of the shafting and the size of the rotating masses can almost always be chosen so that the working range will be free of severe criticals. With installations working in an extended range of speed it is only in exceptional cases that the elements of vibration can be arranged so that this extended field will be free from criticals. In such cases the custom has been to close certain critical fields of speed ranges, notwithstanding the attending annoyance to operation. In other words, the running of the engine at certain speeds has been avoided. This did not altogether prevent the possibility of damage, for the critical speeds had to be run through in passing from one speed to another; it was simply a matter of how often this had to be done and how often the shafting and other material could stand the exposure to these vibrations.

For those installations requiring an extended regulation of the number of revolutions, the design of automatic vibration-dampers is indicated. Such installations include all high-speed Diesel engines for marine purposes, especially Navy vessels, where any speed within the range of the engine is required. Furthermore, all Diesel-electric power units in which the output of power is regulated by the change in speed of the generators.

[1] Consulting engineer, Dortmund, Germany.

[2] Consulting engineer, Philadelphia.

[3] See *Transactions of the American Society of Mechanical Engineers*, vol. 50, paper APM 50-8.

as for instance in Diesel-electric locomotives, come in this category; automobile and airplane engines are likewise subject to critical speeds that cannot be disregarded.

Only recently has the necessity for renewing airplane-engine crankshafts after a relatively short time been ascribed, not to the ordinary fatigue of the material, but to the resonances due to the critical speeds induced by the power impulses. We may further point out that critical speeds will appear even in radial engines in which all the connecting-rods are connected to one crank, especially if the engine and the propeller are connected by some form of flexible clutch or if further elasticity is added by introducing a speed-reduction gear.

### Classes of Torsional-Vibration Dampers

The devices for damping torsional vibrations which have appeared in practical use lately may be arranged in the following groups:

(1) Devices that permit changing the natural vibration of the shaft and the mass system during operation, particularly by
  (*a*) Changes in the elastic character of some part of the shafting
  (*b*) Changes of or additions to the masses
(2) Hydraulic throttling dampers
(3) Damping flywheels having mechanical friction
(4) Damping flywheels having hydrostatic couplings, as distinguished from hydrodynamic types

Several other methods of damping have been proposed; for instance, reduction of the imposed forces by a change in the relative position of the cranks in a multicylinder engine. In this way the resulting harmonic torques within the engine may partly or completely balance each other. Proposals to this effect have been made by H. Wydler[4] and George J. Dashefsky. From the point of view of the vibration technician, these proposals are highly interesting. They are objected to, however, by the practical engineer, not only on account of the difficulties introduced in designing and manufacturing the engine, but also on account of the disturbances introduced in balancing the engine and the uneven turning-moment with two cylinders firing stimultaneously. At any rate, so far as is known, no engine has been built in this way, although the proposal dates back to 1922.

A further possibility in overcoming torsional vibrations lies in the development of special power-transmitting couplings. The present paper deals, however, only with vibration dampers proper, leaving out of consideration all designs of power-transmitting coupling.

### Devices for Changing the Elasticity of the Shaft

The natural vibration of the shaft and mass system is increased with the increase of the stiffness of the shaft when the mass is not altered. The influence of a change in the elasticity is particularly great with a change in the part of the shaft where the node is located. The node in most cases will be in the piece connecting the driver, for instance the Diesel engine, and the driven part, for instance the electric generator.

If we now introduce between the driver and the driven part a very elastic intermediate member, such as a long, thin shaft, then we will obtain a lower natural frequency. Raising the natural frequency is possible by surrounding the thin shaft with a hollow shaft consisting of two parts, one of which is connected to the forward end of the thin shaft and the other to the after end. Both hollow shafts can then be rigidly connected by a clutch while running. With this clutch thrown in, the power is transmitted by the much stiffer hollow shaft, and the natural frequency of the system is raised. Further details of this device may be found in a paper by George J. Dashefsky, entitled Elimination of Torsional Vibration[5], which was read at the June, 1930, meeting of the American Society of Mechanical Engineers at State College, Pa.

This coupling must be very carefully made and fitted, because the least play would cause severe knocks. It must also be made of such liberal dimensions that it can transmit, in a single-acting, four-cycle engine, a turning moment of four to five times the engine mean turning-moment and at the same time admit of no give where the parts are fastened to the thin shaft. As already mentioned, the device is most effective if inserted in the part of the shaft where the node is located. If we are dealing with a two-noded as well as a one-noded system, we face other difficulties, because the location of the node for one-noded vibrations is different from the location of the node of another mode of vibrations. This arrangement further demands sufficient room between the engine and the generator to permit the introduction of the clutch and parts of the hollow shaft, which is seldom available.

### Devices Permitting a Change of the Rotating Masses

If we do not disturb the elasticity of the system, then the rule obtains that the higher the natural frequency is, the smaller are the masses. Inversely, the frequency is lower in proportion as the masses are increased. In general, the masses affect the natural frequency in proportion to their distance from the node. The angular deflection likewise increases with the distance from the node. In most cases this point is the free end of the engine crankshaft. If we now place an additional free disc at this end, then the natural frequency can be reduced if, during operation, we connect this disc rigidly to the shaft by a friction coupling or other device. Judging from published information, this method was first proposed by Professor Tolle in 1915. In principle, it is really exactly the same as that already described under Devices for Changing the Elasticity of the Shaft, the only difference being that the natural frequency is raised, with the quill shaft, whereas with the added disc the natural frequency is lowered.

If the intermediate shaft in a device permitting a change of the rotating masses is made of the same stiffness as the quill shaft and the additional disc is made of such dimensions that the natural frequency is reduced so as to agree with the natural frequency of the system 1*a*, then we obtain exactly the same proportion as indicated by the resonance curves of Figs. 34 and 35 in the paper by George J. Dashefsky[5]. A comparison of these methods shows that the reduction of the natural frequency by an additional rotating mass has the advantage that a relatively small flywheel on the forward end of the 10-cylinder engine suffices to obtain the desired result and that the holding power necessary is less than 10 per cent of that required of the main coupling. In addition a slight vibration of the additional rotating mass in the critical range does not have the same disagreeable consequences as is the case with the quill shaft. In fact the added rotating mass acts then as a friction damper. At any rate, the added rotating mass seems superior to the asynchronizer as regards volume, weight and the cost of production.

Both devices described have the drawback that they do not act automatically but must be cut in or cut out by hand. This is annoying and unreliable with frequent maneuvering. An electromagnetic coupling in connection with a speed governor has been tried in connection

[4] See Drehschwingungen in Kolbemaschinen-Anlagen, by H. Wydler.

[5] See Pennsylvania State College Engineering Experiment Station Technical Bulletin No. 12.

with coupling the additional flywheel, but such an arrangement is not desired either aboard ship or on other types of mobile installations.

### Hydraulic Throttling Dampers

That a ship's propeller, revolving in the water, exerts a damping effect in cases of torsional vibrations has been known for a long time. That this damping capacity of the propeller has been of so little practical consequence is due to the fact that, in high-speed installations, the so-called major vibrations are due to the mass

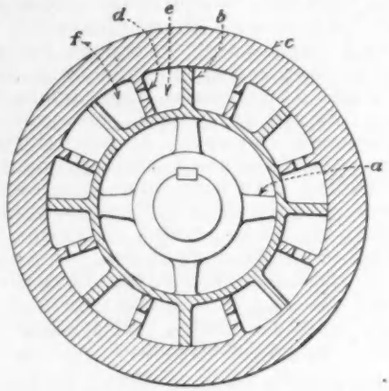



FIG. 1—DIAGRAMMATIC EXAMPLE OF THE HYDRAULIC THROTTLING DAMPER

In This Design, the Damping Results from the Throttling of the Fluid in Passing from One Chamber to Another

of the engine parts vibrating against the mass of the flywheel or the transmission gear or, as in the case of submarine boats, against the rotor of the generator. With this mode of vibration, the amplitude due to the propeller is very small and consequently cannot exert any damping effect.

Attempting to utilize this knowledge in the construction of vibration dampers was, however, natural and, up to a short time ago, most dampers were made with this principle in view. Fig. 1 represents diagrammatically a damper of this kind. A carrying disc *a*, with radial ribs *b*, is keyed to the end of the shaft having the larger deflections. The additional rotating mass *c* is free to revolve on the shaft. It also has radial ribs *d* that, in connection with the end walls, form several chambers filled with a fluid such as lubricating oil. The flywheel-rimlike piece *c* tends to turn with a uniform angular-velocity. Within the range of the critical speeds, the carrying disc *a* will vibrate, thus exerting a pumping effect upon the enclosed fluid by forcing the fluid from the chambers *e* into the chambers *f* and vice versa through the indicated throttling holes in the walls *d*. Means such as springs must be provided to return the piece to its central position as shown.

The damping effect is dependent upon the throttling of the fluid in passing from one chamber to the other. To explain the manner of working of this type of damper, we refer to Fig. 2, in which the resonance curve is shown by the full line. In this case a critical vibration of the sixth order in a six-cylinder engine is assumed. The natural frequency of the system is then assumed to be 2400 vibrations per min. The free part of the damper *c* must have such a mass that the natural frequency will be reduced from 2400 to 2160 vibrations per min. when this mass is rigidly connected to the shaft. The resonance curve for the sixth order would then be represented by the curve shown by the dotted line.

If we now assume an infinitely great throttling—that is, everything tight and with no opening to permit of the passing and repassing of the fluid—then the shaft-mass system would have a natural frequency of 2160 vibrations per min. as shown by the dotted-line curve. The other extreme would occur with the openings so large as to offer almost no resistance whatever to the passing of the fluid, and the natural frequency would then amount to 2400 vibrations per min., with the vibration of the sixth order as indicated with the full-line curve. It is easy to realize that a change in the range of the criticals must occur when the throttling takes place. The damping is therefore effected by this particular action and reaction between the carrying disc and the free member.

Many dampers of this type have been made for experimental purposes, but little information is available regarding their practical use. The reason for this may be the fact that no damping effect by throttling can take place until the amplitude of the vibration reaches a certain magnitude, and this energy of vibration must then be absorbed. Even with forced circulation and cooling of the fluid to absorb the heat generated, the deflections in a dangerous range of criticals cannot be reduced by more than about 50 per cent. In addition, the throttling effect varies with the viscosity of the fluid, that is, with its temperature.

These throttling dampers are, however, comparatively simple to manufacture. Where a reduction in the vibrations of 50 per cent is satisfactory, they may be used to advantage. Junkers has developed such a hydraulic damper that has been fairly satisfactory with aviation engines of various manufacturers. These dampers have been calculated and executed with great care. Further information is given in the thesis for the degree of doctor presented by Franz Neugebauer entitled Schwingungsdaempfung bei endlicher Dampfeztraegheit mit Anwendung auf die Drehschwingungen con Kurbelwellen für Flugzeugmotoren[6].

### Damping Flywheels with Mechanical Friction

Mechanical-friction dampers are constructed so that the additional rotating mass is free to revolve on the end of the shaft. Springs or screws pressed closely to a carrying disc keyed to the shaft cause friction between the carrier and the free rotating mass, which gradually makes the free piece revolve with the same velocity as the shaft and the fixed carrier.

Experience with this type of damper is given in the paper by J. P. den Hartog and J. Ormondroyd, entitled Torsional Vibration Dampers[7], at the 1929 Annual Meet-

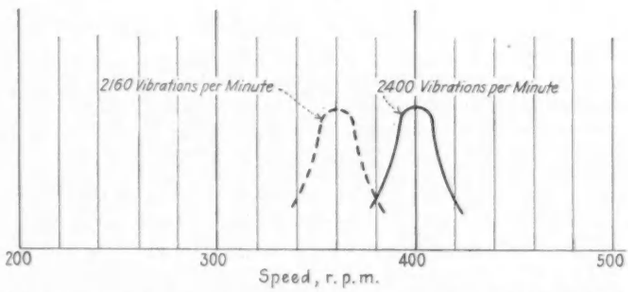



FIG. 2—RESONANCE CURVES FOR A CRITICAL VIBRATION OF THE SIXTH ORDER IN A SIX-CYLINDER ENGINE

The Curve for the Natural Frequency of the System, 2400 Vibrations per Min., Is Shown by the Full Line. When the Frequency of the System Is Reduced to 2160 Vibrations per Min. by the Application of a Damper, the Resonance Curve Would Assume the Form Indicated by the Dotted Line If the Damper Were Rigidly Coupled

[6] See *Zeitschrift für Technische Mechanik und Thermodynamik*, vol. 1, nos. 4 and 5.
[7] See *Transactions of the American Society of Mechanical Engineers*, vol. 52, paper APM 52-13.

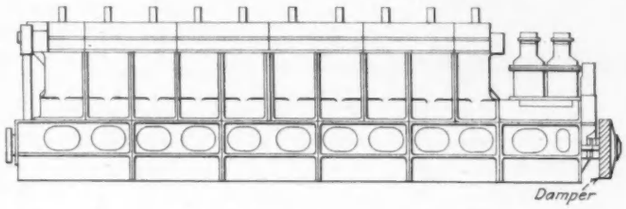



FIG. 3—HYDRAULIC COUPLING FOR A LARGE 10-CYLINDER DIESEL ENGINE

ing of the American Society of Mechanical Engineers. In this paper a very interesting theory is also developed regarding the effect of friction dampers. The statement is made now and then that the effect of the friction damper is comparable with the hydrodynamic damper. Sometimes the "mechanical friction" in the one case is compared with "hydraulic friction" in the other case. This is not correct, for a comparison of both devices with the application of the resonance curves of Fig. 2 shows that, if we consider the additional rotating mass as rigidly connected to the shaft, no vibrations whatever will arise at 400 r.p.m. If we now choose to press the rotating piece too closely to the carrying disc by springs or otherwise, the free piece is compelled to make all the irregular movements with the shaft without slipping. Then the effect as regards vibrations would be the same as if the free piece were rigidly connected to the shaft. This condition of rigid connection can, of course, never be attained with a throttling damper like that illustrated in Fig. 1.

If we now consider the conditions at 360 r.p.m., we find synchronism of the vibrations of the sixth order and violent vibrations occurring with the additional rotating mass permanently fixed. As the damper was to be attached to the end of the shaft with the greater deflection, in a high-speed six-cylinder engine the deflection may amount to ± 1 to 2 deg., and a considerable force is required to make the additional weight take part in these vibrations. However, at the instant when the weight slips, the resiliency is reduced or disappears and the conditions for the resonance are disturbed so that the vibration can attain only a small amplitude.

The whole question involved in calculating the effect of a friction damper is concentrated on the magnitude of the slip moment required to hold the free weight rigidly at 400 r.p.m. The magnitude of this moment is proportional to the turning moments affecting the crankshaft and for which it must be designed under any circumstances. It is not absolutely required that there be no slip whatever at 400 r. p. m. Even if a slight slip takes place, damping will occur comparable to what happens in a hydraulic damper in the same range of critical vibrations. Although the required slip moment, as shown in the following example, is relatively small, adjusting the friction between the carrier and the free weight to admit of any slip in the original range of vibration—that is, at 400 r.p.m.—would be altogether wrong.

Vibrations of the fifth order within the working range of a single-acting four-stroke 10-cylinder high-speed Diesel engine of 3000 hp. required damping. As has been explained with reference to Fig. 2, the damping mass must have a certain fixed minimum moment of inertia to reduce the natural frequency to a noticeable degree. To assure that the required mass would not slip within the original range, a slipping torque or slip moment of from 180,000 to 200,000 lb-in. was required. With this adjustment no vibration whatever of the fifth

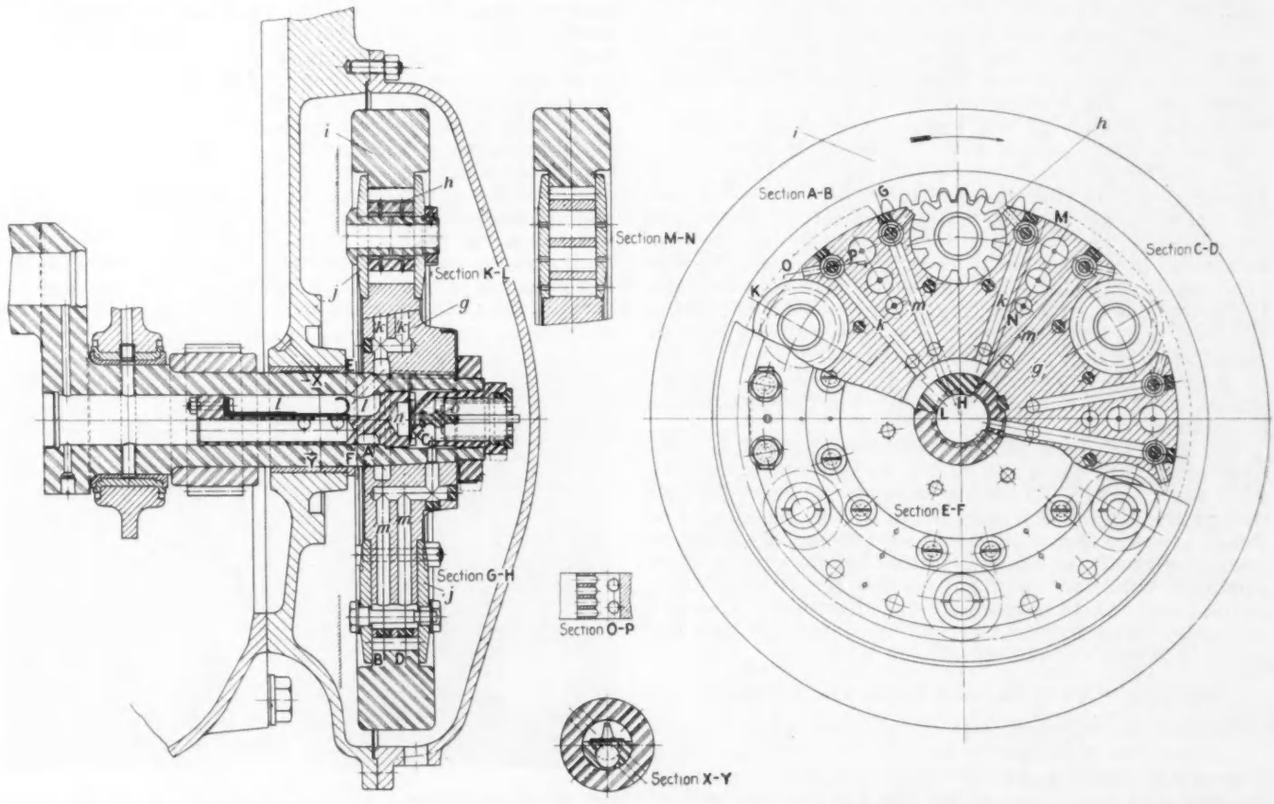



FIG. 4—DAMPING FLYWHEEL WITH HYDRAULIC COUPLING FOR A SMALL DIESEL ENGINE HAVING SIX CYLINDERS

In This Design the Revolving Mass Is Very Large Because the Natural Frequency Is Very Low Since the Connections between the Engine and the Driven Machine Cause Exceedingly Violent Vibrations of the Third Order within the Running Range

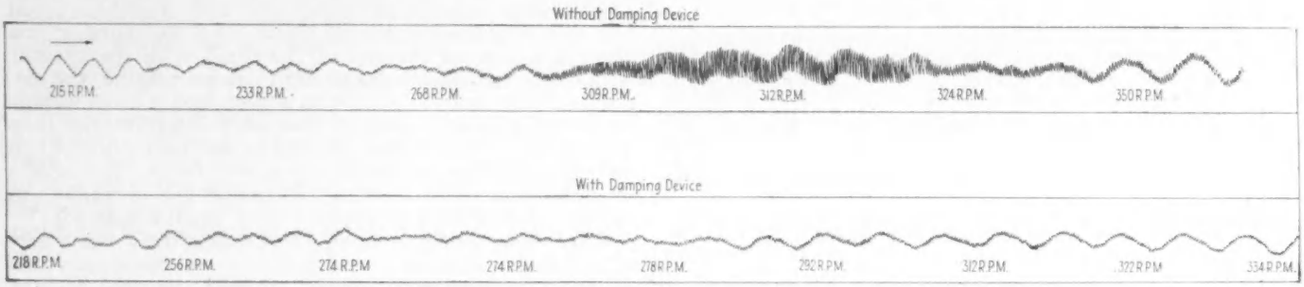



FIG. 5—TORSIOGRAMS SHOWING HOW THE APPLICATION OF A HYDROSTATIC DAMPER AFFECTS THE VIBRATIONS

order was noticeable in the original range. The torsiograms taken under these conditions were exactly the same as those taken with the added revolving mass rigidly fixed to the shaft. Within the lowered vibration-range the oscillations will assume such a magnitude that the inertia forces of the added revolving mass must balance the slip moment, and the crankshaft is now exposed to an additional turning moment. The piston forces in this machine produce a maximum turning moment of about 1,300,000 lb-in., so that the additional turning moment amounts to not over 15 per cent. This is exceedingly small in proportion to the inertia forces that would appear with vibrations of the fifth order without damping, which reach a value of at least 4,000,000 lb. in addition to the maximum torque.

The usefulness of a friction damper is thus shown, and we only have to determine the exact value of the added revolving mass and the slip moment. The damping effect is considerably better than with a throttling damper if the adjustment is correct, and in many cases the dangerous resonance ranges can be reduced to from one-fifth to one-eighth of the original value.

Practical application of this type of damper presents several difficulties. Den Hartog and Ormondroyd in their paper[8] refer to the changeability of the friction coefficients. The coefficient of friction is very dependent upon the shaking of the engine, and when a unit is exposed to heavy shaking, the coefficient of friction will be considerably reduced. Furthermore, a disagreeable characteristic is that the coefficient of friction at rest is greater than the coefficient of friction in motion. Consequently the auxiliary rotating members, when set in motion by the torsional vibrations, will rush farther than really intended. All these drawbacks to mechanical friction are, of course, much more evident the larger the devices. Larger friction dampers can be used as safety devices only; they cannot operate for any length of time in the range of speeds in which the slipping occurs or in cases where the full range of revolutions is required.

The figures given for the 3000-hp. engine are sufficient proof that using the device for any length of time with such turning moments without overheating and cutting the friction surfaces is out of the question. For small engines, however, such as automobile and the smaller aircraft engines, friction dampers have been employed with fair results provided the damper is to be used as a safety device only and that the engines are not called upon to run any length of time within the range of severe critical vibrations.

### Damping Flywheels with Hydraulic Coupling

The damping flywheel with hydraulic coupling is built upon the same principle as the friction damper, but a hydrostatic coupling has been selected for connecting the fixed and movable parts in place of the mechanical friction of the other design. As regards the effect of the damper, the size of the additional rotating mass and the magnitude of the slip moment, everything is the same as stated for the friction damper. Fig. 3 shows the relative size of a damper for normal conditions for the 3000-hp. Diesel engine.

Fig. 4 shows a practical design for a damper of this type for a small high-speed six-cylinder engine. The revolving mass in this case is very large because the natural frequency is very low, due to the particular connection between the engine and the driven machine causing exceedingly violent vibrations of the third order within the running range. This vibration field is very extensive and the additional revolving mass must be chosen large enough to bring the new critical-speed range well below the original one so that they do not overlap.

In this design of damper, a disc, $g$, is keyed to the extended free end of the crankshaft. This disc has several cylindrical holes containing gear pinions $h$. These pinions are geared to a ring, $i$, with teeth on the inner side. The pinions and the ring are kept in place by covers $j$ but can move in the holes and between the end covers; thus we have several gear pumps inside the large wheel. The drawing shows channels $k$, leading from one side of the pinion to the chamber $l$, bored in the crankshaft, and the channel $m$, leading from the other side of all the pinions into the chamber $n$. When the ring turns in the direction indicated by the arrow, the fluid, which is lubricating oil that is supplied to the chamber in the crankshaft, will be sucked through the channels $k$ and forced out through the channel $m$. The pressure chamber $n$ is closed by a spring-loaded discharge or safety valve, while the chamber $l$ is provided with a finger suction valve. A movement of the rotating mass in the opposite direction to that indicated

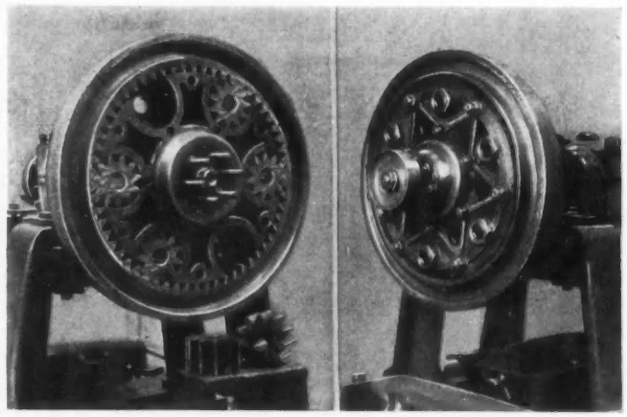


FIG. 6—HYDROSTATIC DAMPING DEVICE FOR A SIX-CYLINDER FOUR-CYCLE ENGINE DEVELOPING 600 HP. AT 700 R.P.M.

The Outside Diameter of the Slipping Flywheel Rim Is Approximately 26½ In.

[8] See *Transactions of the American Society of Mechanical Engineers*, vol. 52, paper APM 52-13, p. 135.

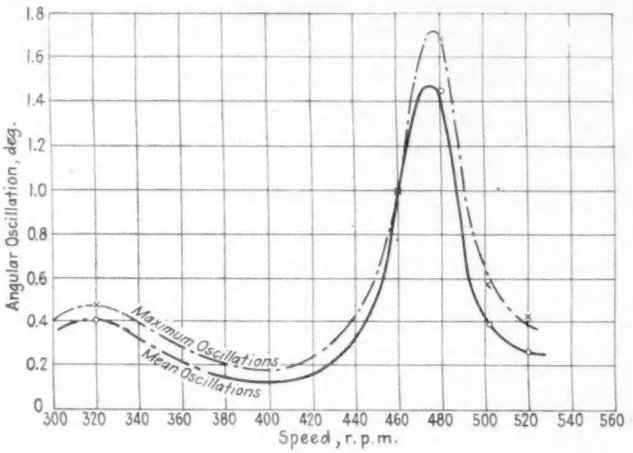



FIG. 7—RESONANCE CURVES PLOTTED FROM TORSIOGRAMS TAKEN FROM A 600-HP. SIX-CYLINDER FOUR-CYCLE ENGINE

These Curves Show the Great Amplitude of the Sixth-Order Vibration When Measurements Were Taken at the Damper Shaft End with the Extra Flywheel Rim Omitted

is not possible because of this arrangement of the valves, which produces an action like that of a ratchet gear. Providing additional sets of valves to act in the opposite direction would be easy enough, but practical experience has shown that this is not absolutely necessary. Further, whether the revolving mass moves in advance of the crankshaft or lags behind makes no difference.

If a vibration takes place at the end with the disc $g$ in a direction opposite to the one indicated by the arrow, then the revolving mass $i$ may turn clockwise provided the hydrostatic pressure in the canals $m$ and in the pressure chamber $n$ is sufficient to open the valve $o$. The turning moment required is directly proportional to the hydrostatic pressure. No further elucidation is required to see that the connection between the revolving and the stationary parts is identical with a mechanical-friction arrangement provided that the gearing is well fitted and without backlash and that care has been taken to have no air in the pressure channels or chamber. All of these requirements can be taken care of without difficulty.

With this arrangement a circulating oil system is provided inasfar as oil is sucked from the space in the crankshaft and forced through the safety valve $o$ into the stationary chamber. The oil is then returned from the latter to the oil container. The heat generated by the slipping of the revolving mass when in the critical speed-range is thus automatically carried off. The quantity of heat is rather less than with a friction damper, first because the slip moment is considerably reduced on account of the absolute exactness and permanence with which the pressure valve can be adjusted, and next because the hydraulic coupling is not subject to the variation of the coefficient of friction obtaining in a mechanical friction damper where the coefficient of friction is greater for the state of rest than when in motion. On the contrary, the slip can commence with a lower turning moment by suitably dimensioning the valve and stiffening the spring, thus requiring a greater turning moment for the increase in slip. Intensive comparative tests have shown that, under perfectly equal conditions, the hydraulic damper has only from 10 to 20 per cent of the slipping motion of the friction damper.

As regards the reliability of the hydraulic damper, it must be remembered that the dimension of the gears is not determined by the forces involved but simply by the volume of fluid to be conveyed; therefore the teeth are only loaded to between 15 and 20 per cent of their normal capacity. Another consideration is that the relative motion between the parts is very slight, never more than one relative turn per minute between the disc and the revolving mass having been observed, and that the whole outfit is nothing more than a number of small gear-pumps within a common large wheel, moving as a unit, completely filled with lubricating oil, and at most making 1 r.p.m. As a result of practical experience over a period of three years, the hydrostatic damper has been found reliable and consistent in performance. It has been in use on a large 10-cylinder engine, among others, running in the critical-speed range of the fifth order day after day without the least indication of trouble.

### Results of Tests

Fig. 5 reproduces torsiograms showing the respective ranges of vibration, one with, and the other without, the hydrostatic damper. Piston or other positive acting pumps may be, and have been, utilized in place of gear pumps. As regards comparative reliability, no difference has been found whether designed in one way or the other. The dimensions, weight and cost of the damper relative to the cost of the engine to be protected is so low that they should be no obstacle to its adoption. Practical examples worked out in connection with various types and sizes of engine have proved that the figures for weight and cost average about 2 per cent of those of the whole engine.

Fig. 6 shows a hydrostatic damping device for a six-cylinder, four-cycle engine, developing approximately 600 hp. at 700 r.p.m. The outside diameter of the slipping flywheel rim is about 26½ in. Figs. 7, 8 and 9 show resonance curves plotted from the torsiograms taken from this engine.

The damping device was not designed for the conditions prevailing on the trial stand, for which the flywheel effect of the slipping member of the device should

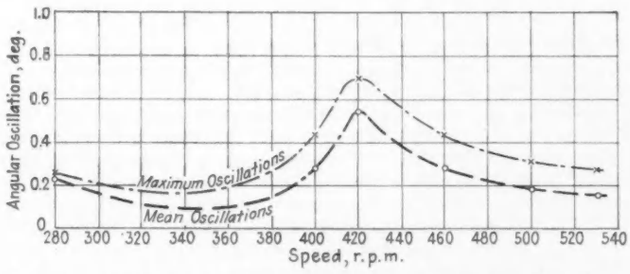



FIG. 8—ANOTHER SET OF RESONANCE CURVES FROM THIS ENGINE

When These Curves Were Taken, the Damper Was Adjusted with a Slip-Torque of Approximately 30,000 Lb. The Vibrations Shown in Fig. 7 at Approximately 475 R.P.M. Have Disappeared, While Others Are Noticeable at 420 R.P.M.

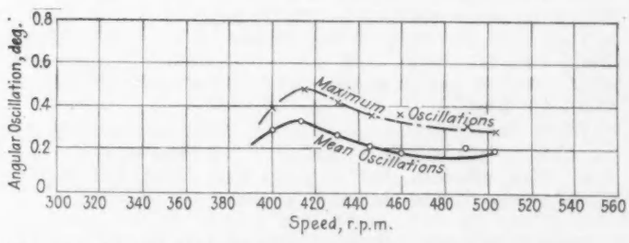



FIG. 9—DECREASING THE SLIP TORQUE IN THE SAME ENGINE TO 20,000 LB. GAVE THIS SET OF RESONANCE CURVES

The Marked Difference in the Effect of the Damper Resulting from This Comparatively Small Change in the Slipping Torque Is Especially Noticeable

have been somewhat larger. Fig. 7 shows the large amplitude of the sixth-order vibrations occurring at about 475 r.p.m. In Fig. 8 the damper was adjusted with a slip torque of about 30,000 lb-in. The vibrations at about 475 r.p.m. have practically disappeared, while vibrations are noticeable at 420 r.p.m. Comparing Fig. 7 with Fig. 8 shows that the flywheel effect of the damper should have been so much larger that this lower critical range would have been shifted down to about 400 r.p.m. The sticking power of the device was then decreased to about 20,000 lb-in., with the result shown in Fig. 9. Special attention must be directed to the considerable difference in the effect of the damper between the comparatively small alteration of the slipping torque from 30,000 to 20,000 lb-in. Obviously no mechanical-friction damper could ever be designed to obtain a constant slipping torque within such close limits. The damping flywheel with hydrostatic coupling is therefore a device by the use of which (*a*) the vibration of shafting of the largest engines, even when running in the most dangerous speed-ranges can be damped and (*b*) running at all speeds without regard to any vibrations and without the necessity of operating a damping device by hand is possible.

## THE DISCUSSION

CHAIRMAN W. F. JOACHIM[9]:—I do not believe that the importance of torsional vibration has been brought home as forcibly to the members of this Society as it has to the Society of Naval Architects and Marine Engineers. Certain astounding disasters of considerable moment have occurred in the last decade which were due to breakages of crankshafts. Stresses in the shafts, calculated from the normal-torque curves, have been so low as to indicate that either some flaw must have existed in the steel or something wholly unknown at that time was taking place.

Later, the fact was recognized that, where an engine is coupled to a rotating mass of considerable inertia, the engine crankshaft might vibrate or twist backward and forward at its natural frequency, like a reed held at one end while still turning in the direction of rotation. This torsional twisting is amplified or maintained by the coincidence of the power impulses from the pistons with the vibrations. This condition of resonance between natural frequency and power impulses causes the large stresses that finally produce shaft failures. The engine speeds at which resonance occurs are the critical speeds.

As a matter of fact I have in mind a 22-in. shaft between a turbine and a generator, where the normal stresses were very low, which got into a critical vibration that broke it as though some giant had twisted it in two. Similar shaft-breakages occurred in submarines and larger Naval vessels.

While we have had only few such occurrences in automotive and aircraft engines, the crankshaft failures which occurred in the Graf Zeppelin's engines are still fresh in our minds.

O. D. TREIBER[10]:—Those of us who build Diesel engines know that torsional vibration is the biggest keg of dynamite which we have. I have known of a case where the crankshaft was running in a torsional period, but the engine was just as smooth and apparently had no vibration of any kind, and that crankshaft broke in 24 hr. of running. I have seen 5-in. shafts about 5 ft. long, connecting an engine with a dynamometer, which became red hot between the bearing of the dynamometer and that of the engine in 4 hr. of running. That was the node, and the continual twisting of the shaft at this point would cause it to get red hot and crack in 4 hr.

With the higher-speed engines, the mass becomes less because of the higher number of revolutions per minute. Nevertheless, the engines are running in speeds that harmonize the natural frequency of the crankshaft with the forced vibrations in a much more pronounced way than they did in the slower speeds. I hope that all of the men who give their thought and time to the development of automotive Diesel engines will bear in mind that important factor, because if we do not we will get into difficulties that will not only hurt the industry but also will be an awful black eye to whoever is responsible for them.

### Critical Discussion of Dampers

J. ORMONDROYD[11]:—A damper is essentially a machine for the production and dissipation of energy. Four types of damper have been put into use in the last few years. These are

(1) Lanchester friction
(2) Lanchester with metallic and organic springs
(3) Hydraulic
(4) Hydrostatic

The action of all these types of damper is essentially the same, that is to say, they all consist of a heavy flywheel driven from the vibrating shaft by frictional or elastic connections or a combination of both. Up to certain limits they all have damping powers proportional to the flywheel inertia and dissipate energy by relative motion and friction between the flywheel and the vibrating shaft. They offer among themselves varying degrees of convenience in design and manufacture and maintenance. They also vary somewhat in the amount of energy which can be dissipated by them under the given conditions of exciting-torque amplitude, natural frequency of the engine and flywheel inertia.

The Lanchester damper, the dynamic vibration absorber with friction and the hydraulic damper are all capable of theoretical treatment. Design theories have been developed for all three, and actual tests have been made indicating that these theories are correct. By these design theories all these dampers can be worked at their optimum adjustment. The complicated action of the Sandner hydrostatic damper makes the development of a simple design theory almost impossible. I assume that no such theory exists, since it has not appeared in any published work uptodate. Therefore, the design of each separate damper must be a cut-and-try process. For a given flywheel moment of inertia, natural frequency of vibration and amplitude of disturbing torque, a definite optimum combination of oil viscosity, oil-passage size and relief-valve loading must be found. Without a definite design theory, finding this best combination is impossible except by pure accident.

The hydraulic damper and the dynamic vibration absorber with springs are both capable at their optimum settings of holding the vibration amplitude to smaller values than the Lanchester damper. They are not extensively used only because of practical difficulties in

[9] M.S.A.E.—Formerly senior mechanical engineer, Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.

[10] M.S.A.E.—Chief engineer, Diesel engine division, Hercules Motors Corp., Canton, Ohio.

[11] Manager of experimental engineering division, South Philadelphia Works, Westinghouse Electric & Mfg. Co., Lester, Pa.

construction and maintenance. The dynamic vibration absorber with springs is in fairly common use with leaf springs or rubber discs as a means of combining frictional energy dissipation with elastic connections. At its optimum setting, the hydraulic damper is capable of reducing the amplitude of vibration to 81 per cent of the best value possible with the Lanchester damper under the same conditions, but the difficulty of maintaining oil viscosity and producing the optimum oil-flow clearances seems to make this damper impractical from a commercial point of view.

The Sandner hydrostatic damper, dissipating energy over only one-half of the vibration cycle, must be incapable of reducing the vibration amplitude as much as the Lanchester damper under similar conditions. Its action must depend very much upon the variation of oil-pump leakage around the edges of the plate that holds the gear pumps in the flywheel. These plates must be tight enough to keep oil leakage at the minimum, and at the same time they must allow the flywheel to move freely. To see from Fig. 4 how these conditions can be met practically is rather hard. This same figure also does not show clearly how any oil leakage can be made up, in other words how the oil circuits can be kept free from air, neither does it indicate the path of the oil between valve *o*, chamber *n* and the relief-valve in chamber *l*.

### Lanchester Damper Cheap and Efficient

As far as cheapness of manufacture goes, the Lanchester damper is absolutely the cheapest of the four. It is made of simple circular parts in which the only machining operations are turning and drilling. The dynamic vibration absorber is next in cheapness, the hydraulic damper is third, and the Sandner is evidently the most expensive of all to manufacture under the same manufacturing conditions.

Messrs. Sandner and Frauenfelder state that the action of the Lanchester damper is erratic. In the past, Lanchester dampers have been installed in such a manner that their performance has not been completely predictable, but this unfortunate circumstance has been completely eliminated by lubricating the friction plates in a definite manner. This, of course, lowers the coefficient of friction, which then remains constant throughout the life of the damper and merely requires heavier loading springs. The coefficient of friction that affects the Lanchester damper is the dynamic coefficient, which has been determined by actual vibration-tests and steady-rotation tests and is known to be about 0.09 to 0.10 for ordinary brake-lining materials lubricated and pressed together with normal pressures of 100 lb. per sq. in. or more.

The Lanchester damper has the extreme advantage of staying out of action until the motion starts to get rough, and its flywheel will not slip until the amplitude of motion has become 45 per cent of the amplitude to which the damper is designed to hold the critical vibration. This value of 45 per cent holds for frequencies near the natural frequency of the engine. Thus we see that the Lanchester damper is really a flywheel until frequencies near the natural frequency have been reached, which means that the wear on the damper friction plates is very slight. The actual wear on practical Lanchester dampers is so small that its extent is still debatable after four or five years' service in the field, and the maximum wear ever measured in a damper that had been in service over one year was 0.02 to 0.03 in. Lanchester dampers have been run continuously under resonant conditions and the energy dissipated raised the average temperature of the damper 30 deg. fahr. A good damper designed to operate at its optimum effectiveness on a six-cylinder engine at the sixth-order vibration will not dissipate at resonance more than ½ per cent of the nominal maximum horsepower of the engine. In fact, with dampers, we have the paradox that the better the damper, the smaller the energy dissipated at resonance. This follows from the fact that the input energy and the output energy balance at a lower amplitude of motion with a better damper.

All the dampers mentioned in this discussion will act effectively. The ultimate choice of the damper will be determined by practical considerations of cost, ease in manufacture, ease in maintenance and possibility of rational design. Because of these considerations, I believe that the Lanchester damper will ultimately remain the only damper in wide-spread use.

ERICH SANDNER:—The action in the hydrostatic damper is not complicated. Under the assumption that *rigid* coupling is obtained between the primary parts of such a damper and the flywheel rim until the slipping torque is exceeded, obviously the manner of functioning of the hydrostatic damper must be, in principle, exactly analogous to that of the Lanchester friction damper and whichever design theory holds good for the friction damper will be equally valid for the hydrostatic damper. The moment of inertia of the slipping flywheel, as well as the sticking torque, can be determined with the same accuracy as with any other known type of damper without resorting to any hit-or-miss process. Gear pumps cannot be made perfectly tight, but the question is whether they are tight enough to produce the desired result, namely, to obtain rigid coupling of the flywheel in those speed ranges in which no slipping should occur. Figs. 5, 7, 8 and 9 show that this object has been attained in as perfect a manner as can be desired. In Fig. 7, severe vibrations are recorded at 475 r.p.m.; but in the next two illustrations which show the conditions with the damper in action, the vibrations at 475 r.p.m. have entirely disappeared, which is the best proof that the damper has neither backlash nor leakage to any noticeable or objectionable extent.

Contrary to hydrodynamic dampers, the question of the viscosity of the oil does not enter into the functioning of the Sandner damper, except that the internal leakage will increase somewhat. Comparative tests have been made with the same damper, using first a heavy grade of lubricating oil and then petroleum, and the difference in the effect of the damper in the two cases was negligible.

The damper shown in Fig. 4 is capable of dissipating energy in only one direction. With a pressure valve in the one chamber and an automatic suction-valve in the other, the action is similar to a ratchet gear. However, an equal effect can be obtained in both directions of slipping if a spring-loaded pressure-valve *and* an automatic inlet are arranged in *both* chambers *m* and *n*. As a matter of fact, all larger dampers have been provided with such double sets of valves; but for smaller sizes of damper only one set is generally used because, as the result of actual trials, we found that the damping effect is nearly as good if the flywheel is allowed to slip in one direction.

Cheapness of manufacture of the various dampers is of little importance. If the selling price of a hydrostatic damper under usual manufacturing conditions, not mass production, is as low as about 2 per cent of the cost of the engine, whether another type of damper can be obtained at a price of say 1½ per cent of the engine price is rather immaterial. Toothed gears, which form the principal parts of the damper, are now produced by specialists at a very reasonable cost and with great accuracy.

The statement about the very slight wear on friction dampers is surprising and seems to be in contradiction to the experience gained with this type of damper by many other parties, who have carried out extensive tests with dry friction as well as with lubricated surfaces. Many friction dampers, especially of larger sizes, are known to have failed in the long run, not because

they were improperly dimensioned or designed, but because of heavy wear and considerable changing of the slipping torque. If Mr. Ormondroyd had stated whether, according to his experience, a friction damper for the large 10-cylinder engine cited in the paper, and for which a slipping torque of about 200,000 lb-in. was required, could be relied upon to control the engine for hours in the critical range of the fifth order, that would have been very interesting. Obviously, the advantages claimed for the hydrostatic damper are more pronounced in large dampers than in the smaller sizes.

Only a few years have passed since the general engineering world has realized the detrimental effect of torsional vibration, especially in shafts driven by multiple-cylinder high-speed engines, and even today very few such installations exist which can be safely operated over the entire running range of the engine without the necessity of prohibiting running in certain critical speeds. A good field for more than one type of reliable and effective vibration damper exists, and I believe that the best type for the size and purpose of each particular installation will ultimately be chosen.

MR. TREIBER:—I should like to comment on Mr. Ormondroyd's statement that apparently no method exists for predetermining what the torsional-vibration period with the Sandner damper should be, and that getting it right is an accident. The natural frequency of the crankshaft can be calculated, entirely apart from the damper problem, and the magnitude of the vibrations; from these the damper can be predetermined. While the empirical method of doing so has never been printed, to my knowledge, Mr. Sandner has it and makes these calculations continually. Arrangements can be made with him to teach any engineer just how to do it.

We must not forget that with the Lanchester damper we have a coefficient of friction varying widely with changes of heat, expansion of the metal and other things, and that variation affects the damping effect, while with the Sandner damper the adjustment of the valve to take care of different oil viscosities will permit the adjustment of the engine, or rather the entire unit, so that it will cover the entire range under any conditions; and we have practically nothing in the whole unit that will wear out.

Leakage past gears and plates, as mentioned by Mr. Ormondroyd, has not been experienced in those Sandner dampers that have been built, and I know of a gear pump that develops 10,000 lb. per sq. in. pressure continuously. Formerly we did not think that this was possible, but it is being done. When we consider a gear pump for the normal low pressures that this damper has to deal with, we do not worry about excessive leakages that would affect the operation of the damper.

[12] Vibration expert, New York Navy Yard, Brooklyn, N. Y.

[13] See *Transactions of the American Society of Mechanical Engineers*, vol. 52, paper APM 52-13.

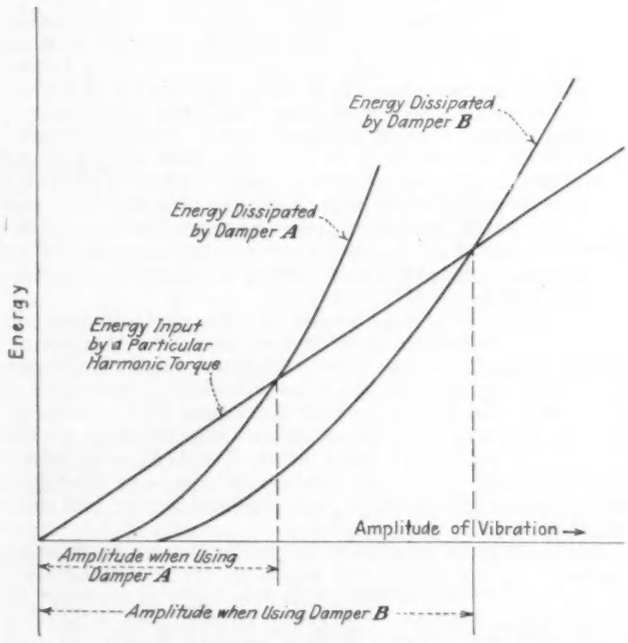

Energy Dissipated by Damper B
Energy Dissipated by Damper A
Energy Input by a Particular Harmonic Torque
Energy
Amplitude of Vibration
Amplitude when Using Damper A
Amplitude when Using Damper B

FIG. 10—ENERGY BALANCE BETWEEN INPUT FROM HARMONIC TORQUE AND DISSIPATION BY DAMPERS

### Limiting Vibration a Matter of Dissipating Energy

GEORGE J. DASHEFSKY[12]:—The authors use the term "damper" rather broadly as applying to any means for reducing vibration. The term "damping" is generally understood to designate a force or torque resisting vibration, and as a result of which energy is absorbed at the places where the resisting forces have been applied.

In explaining Damping Flywheels with Mechanical Friction, the paper regards the slip of the flywheel as destroying the conditions of resonance and for this reason effecting a reduction in amplitude. This does not appear to be the usual conception of action in any type of damper, be it hydraulic, viscous or solid friction, the theory being, rather, that vibration energy is dissipated and that the amplitude prevailing in any installation is of such magnitude that a balance exists between the energy input from the harmonic torques and the energy absorbed by the damping forces in the system, as shown in Fig. 10. Dissipation of energy is a direct consequence of the slip between the vibrating member and the damper flywheel. Based on this theory, Den Hartog and Ormondroyd have shown[13] that, to obtain optimum damping for any particular vibration, a relation exists between the stimulating torque, the moment of inertia of the flywheel element of the damper and the friction torque to which the damper is adjusted. Based on their equations, the optimum damping or dissipation of energy obtains when

$$T = (\pi/4) \vee (2) M \quad (1)$$

$$I = (\pi^2/4)\ (M/p^2 a) \quad (2)$$

where

$a$ = amplitude at the point of application of the damper
$I$ = moment of inertia of the damper flywheel
$M$ = harmonic torque stimulating the particular vibration under consideration
$n$ = frequency of vibration
$p = 2\pi n$
$T$ = friction torque between the damper flywheel and the vibrating member

For damping to occur, slippage between the flywheel element and the vibrating element *must* take place. The flywheel too assumes a vibratory motion. Figs. 11 and 12 are reproductions of vibration records from a damper utilizing viscous friction, but similar results may be expected with any type of Lanchester damper. These graphs show that the flywheel member also assumes a sinusoidal motion, which is essential to the functioning of the damper and must exert an influence on the frequency of the system. Design of a damper on the theory that it acts solely as a frequency-changing device does not appear proper and may fail to lead to the best proportioning of the damper elements.

Whatever the form of the damper, we believe its action in limiting vibration to be a matter of energy dissipation. That the damper does effect a change of frequency in the installation cannot be denied, but this

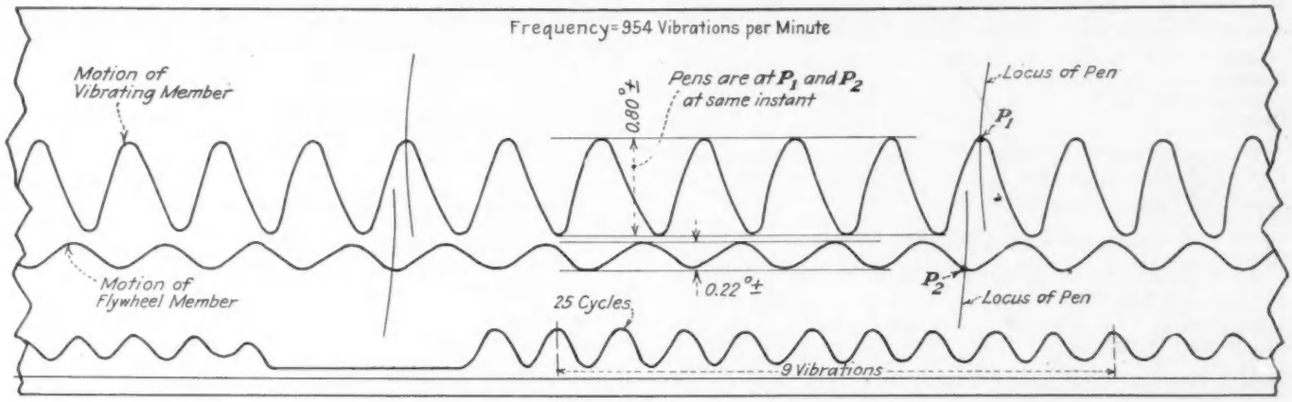



FIG. 11—RECORDED MOTION OF DAMPER FLYWHEEL WITH LIGHT FRICTION TORQUE

cannot be the principal function that results in reduced vibration.

The hydraulic damper described by the authors is indeed ingenious in its construction and mechanically appears to offer more consistent action than does the conventional Lanchester damper utilizing solid friction. Its manner of functioning is analogous in principle to that of the solid-friction damper. The torques resisting vibration result from the pumping of fluid against spring-loaded valves. At a given frequency in both the authors' and the solid-friction damper, a certain minimum amplitude of vibration must be attained before slipping of the flywheel element can take place and the desired damping be obtained.

Depending upon the arrangement of valves as mentioned in the paper, the flywheel is capable of slipping either in one direction or both. The arrangement of the valves to permit slippage in both directions would appear to render the damper more effective as a damping device.

As a general principle, the use of additional apparatus, such as dampers, asynchronizing devices and the like, in an installation should be resorted to only when no other expedient is available. Using such devices means, not only additional elements on the installation, but also an element of whose proper functioning one cannot at all times be certain.

In most cases a single critical speed, whose magnitude is not too great, can be tolerated in the operating range, provided it is located in some unimportant speed belt. In many installations that are properly designed as regards their torsional-vibration characteristics by judicious disposition of the inertial and elastic elements, choice of correct firing order and other similar factors, reasonable conditions may prevail without recourse to vibration-eliminating devices. Advantage can also be taken of the inherent damping properties of an installation.

The ideal installation is one in which the fundamental cause of the vibration has been eliminated. The source of stimulation of torsional vibration lies in the harmonic components of the turning effort of the engine. Partial neutralization of some of these torques exists in every installation having two or more cylinders, the degree depending upon the shape of the normal elastic curve and the firing sequence of the cylinders. Where an installation comprises a large number of cylinders, they can be advantageously arranged to secure neutralization of the stimulating torques. Several arrangements of cylinders which result in practically complete neutralization of all important vibrations are described in my paper entitled, Elimination of Torsional Vibration[14], which was presented at a meeting of the American Society of Mechanical Engineers at State College, Pa., in June, 1930.

The authors criticize the neutralization schemes thus:

> They are objected to, however, by the practical engineer, not only on account of the difficulties introduced in manufacturing the engine, but also on account of the disturbances introduced in balancing the engine and the uneven turning-moment with two cylinders firing simultaneously.

### Counterphase-Neutralization System

Fig. 13 illustrates one arrangement of my counterphase-neutralization system described in the previously mentioned paper. In this arrangement the two principal masses—for example, two flywheel generators or any other driven elements—are by design made of equal $WR^2$. The cylinders are disposed symmetrically with respect to the longitudinal center of the installation. The normal elastic curves for one and two-noded vibrations are as indicated, an interesting point about the latter being that the driven masses are located substantially at the nodes.

Each of the groups of cylinders, 1 to 6 inclusive and 7 to 12 inclusive, constitutes a conventional six-cylinder engine as regards crank arrangement and firing sequence. The cylinders are fired in pairs—1 and 12, 2 and 11, 3 and 10 and so on—as indicated. The resultant engine-torque is of the same character as that of a single 6-cylinder engine which is of the same stroke but whose cylinder area is twice that of the 12-cylinder engine under consideration. In this arrangement the harmonic torques for *all orders* of the one-noded vibration are inherently neutralized as between the pairs of co-acting cylinders. The two-noded mode is of such high frequency, by virtue of location of the large masses at the nodes, that only unimportant critical speeds of very high order fall within the operating range. Each group of cylinders is balanced as regards reciprocating weights and moments. Hence the counterphase arrangement does *not* introduce in the engines any unbalance which did not exist there before. Some sacrifice of torque reaction is made, but this objection becomes less important where a larger number of cylinders is used. The authors' criticisms of the counterphase-neutralization system do not appear valid.

Calculation shows that in a two-cycle installation arranged for counterphase neutralization with nodal drive, as shown in Fig. 13, having 12 cylinders of 29-in. bore and 44-in. stroke and a normal speed of 125 r.p.m.,

[14] See Pennsylvania State College Engineering Experiment Station Technical Bulletin No. 12.

the first synchronous vibrations to be encountered within the operating range are as follows:

| Order | 16th | 17th | 18th |
|---|---|---|---|
| Nodes | 2 | 2 | 2 |
| Speed, r.p.m. | 129 | 121 | 114 |
| Character | Minor | Minor | Major |

Of these, the 16th and 17th orders are practically non-existent, while the 18th-order major will be very small, in fact, of negligible amplitude.

### Asynchronizing Devices

As regards the authors' objection to asynchronizing devices, we feel that no single device or scheme can be a panacea for all vibration ills. Each problem must be considered individually and the proper remedy prescribed. The general scheme of rendering a shafting system asynchronous may utilize either an inertia or an elastic member to effect the required changes in frequency. The authors imply that only one arrangement is possible for the elastic asynchronizer—a quill shaft, stiffer sleeve and clutch—and raise objections to this arrangement because of space requirements. A more compact arrangement embodies a combination of flexible coupling and clutch. This arrangement requires much less space than the equivalent elastic asynchronizer using a quill shaft and sleeve. Automatic instead of manual control of the clutch at the appropriate speeds is, of course, possible.

The authors' objections to the asynchronous shafting, on the grounds that more than one mode of vibration may exist in an installation, can as well be directed at all forms of vibration damper, which usually are most effective for some one particular vibration. Under such adverse conditions, a redesign of the installation in addition to the application of damper or asynchronizer may be necessary.

Mr. Sandner is of the opinion that the inertia asynchronizer is superior to the elastic asynchronizer. While such advantage does appear to exist from superficial examination, a broader consideration indicates that the addition of an inertial mass at the free end of a crankshaft may increase the magnitude of some minor-order vibrations, whose presence may seriously interfere with application of an asynchronizing device. The elastic asynchronizer in the flexible condition tends to decrease the amplitude of *all* minor-order vibrations. Mr. Sandner states that, in event of slipping, the flywheel at the forward end of the crankshaft acts as a damper. While this should not be required of this species of device, the same property also exists for the elastic asynchronizer, as slipping occurs between the two clutch members.

J. BARRAJA-FRAUENFELDER:—All the objections that both Mr. Dashefsky and Mr. Ormondroyd raise have been met with in practice and overcome. Substituting a flexible clutch for the quill shaft is another way to go around the bush which will add to the investment. I am not satisfied that this is a solution from the practical engineer's point of view.

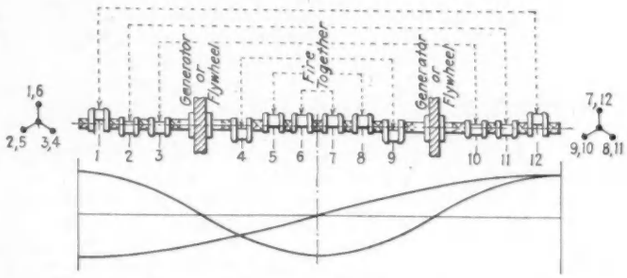



FIG. 13—COUNTERPHASE NEUTRALIZATION AND NODAL DRIVE OF MASSES

Mr. Treiber has been good enough to comment on the question raised by Mr. Ormondroyd, those of calculations and prediction as to what the damper will do. The Sandner damper has done exactly what that discusser says it cannot do, and numerous installations prove this. Mr. Treiber has aptly said that the variables in the friction damper are numerous, whereas in the Sandner type we have to deal only with the viscosity of the lubricating oil, which is very easily taken care of and has been found in practice to have very little effect.

The very nature of the damper lends itself to promptness of action. If the natural frequency of the mass system produces oscillations of say 1½ deg., which is considerable, the damper will catch these oscillations at about 20 per cent of their amplitude instead of 45 per cent as has been stated for some of the frictional dampers. In fact, it has cut them in cases to one-eighth of the would-be amplitude.

The slip of the damper has been found to be only about 0.1 per cent, which is a very small quantity. In a damper for a 3000-hp. submarine engine, such as is described in the paper and which was built as a gear type, after four years' operation, the gears have been found to show the original tool marks. This speaks well for the damper and takes care of the inferred lack of ability of the damper to take care of oil leakages due to excessive wear. The gear-pump construction lends itself to a very practical and simple treatment. The devices, as built now and as applied to engines in existence, have been found to cost less than friction dampers of the same capacity. After all, what the damper actually does cost is the important fact, and it does cost less.

Lanchester-type dampers with springs have another

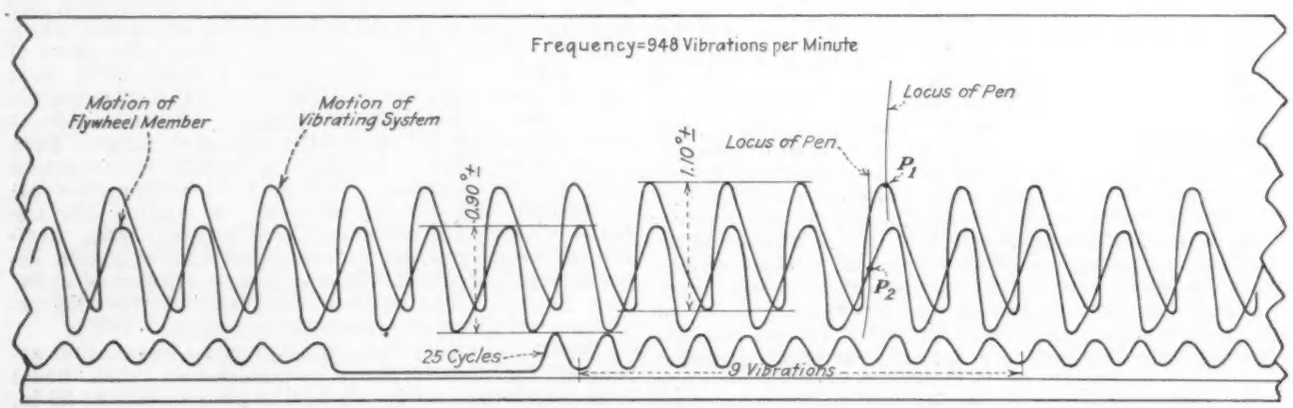



FIG. 12—RECORDED MOTION OF DAMPER FLYWHEEL WITH HEAVY FRICTION TORQUE

variable that has to be taken care of, the natural frequency of the spring itself, which may or may not add complications. This condition exists also in spring-type flexible-couplings intended to act as dampers. It is another undesirable characteristic that has to be overcome by experience, while as Mr. Treiber has said the Sandner type of damper can be calculated exactly for what it has to do.

The breakage of the Graf Zeppelin crankshafts, as mentioned by Mr. Joachim, is a case in point. Those shafts broke because the harmonic characteristics of the lineshaft system were changed through a change in the stiffness of the flexible couplings. Some of the springs are reported to have broken or become worn out and, although spare springs were available, someone on the ship thought that they were not strong enough. These people were not familiar with the theory on which the coupling's design was based, so they proceeded to put the new springs in but inserted some thicker washers under them and eventually installed heavier springs, thus increasing the periodicity of the system. This change brought two modes of vibration within the running range of the engines, as a consequence of which several crankshafts failed. This proves that unknown quantities are present in friction and spring-type dampers which cannot always be correctly gaged.

The G-38, the famous Junkers airplane, has two 800 and two 400-hp. engines and is equipped with Sandner vibration couplings inserted between engines and propellers. That we have been talking about vibration dampers only in the paper and not of damping couplings must be understood, but I am citing this as another important application. Such couplings involve the same principle as the dampers but are used to transmit power as well. These devices have been inserted between the driving and driven members in this airplane. The Junkers people have stated that without them the airplanes could not have been operated successfully. Sandner dampers have been substituted for Lanchester and other types of damper in several instances by at least two of the five most prominent naval powers.

MR. SANDNER:—The statement in the paper that the slip of the flywheel has the effect of destroying the conditions of resonance was neither intended to create any contradiction to the conception that vibration energy is dissipated nor to dispute the correctness or validity of the theory advanced by Den Hartog and Ormondroyd. In fact, energy must be dissipated when the flywheel slips under a certain slipping torque, and an acknowledged technical rule is that balance must always exist between the energy input on one side and the energy absorbed on the other. Whenever the additional flywheel slips, a disturbing factor is introduced into the resonance between the period at which the stimulating torque occurs and the natural frequency of the vibratory system. Amplifying the original statement to read

> The slip of the flywheel has the effect of destroying the conditions of resonance, thereby dissipating vibration energy

would have been better.

The example shown for an application of the counter-phase-neutralization scheme is certainly a noteworthy suggestion. Most of the objections raised against this method in the paper have been overcome by choosing an installation that comprises as many as 12 cylinders in line. The question must be raised, however, whether the prospective owner would not prefer, instead of 12 cylinders and 2 generators, to install two independent units of 6 cylinders each, which would be advantageous for many reasons other than torsional vibration. At any rate, the neutralization scheme proposed by Mr. Dashefsky can be made use of only in exceptional cases.

We fully agree with his remark that no simple device or scheme can be a panacea for all vibration ills. The particular statement in the paper, to which Mr. Dashefsky takes exception, applies equally to any other device.

The additional flywheel mass of an inertia asynchronizer as compared to the elastic asynchronizer might increase the magnitude of minor orders of vibration *if* it should remain coupled with the shaft; but the supposition of the functioning of the inertia asynchronizer is that the additional mass is coupled in only when dangerous or undesirable vibrations would otherwise occur. It offers no difficulties to choose such flywheel effect of the inertia asynchronizer that minor criticals are avoided with the flywheel coupled in. Slipping of the flywheel, of course, is not required and not desired; but, if it should occur for some reason, the slipping torque necessary for the elastic asynchronizer is roughly 10 times greater than for the inertia type, and I doubt whether a clutch can be designed for the larger installations that would allow slipping under such severe conditions.

F. C. MOCK[15]:—While the subject of this paper is damping torsional vibrations, its treatment and the discussion following was extended to the general subject of roughness of operation, which is of even greater importance in automotive Diesel installations than in marine installations. Any consideration of vibrational damping should recognize the essential difference between the following three allied but entirely distinct phenomena:

(1) *Variation of Rate of Angular Rotation*, caused by high rates of pressure change in the engine, and/or too light a flywheel

(2) *Variation of Torque Reaction*, on the engine supports or on any gearset through which the drive is transmitted, due to high rate of pressure change in the engine

(3) *Torsional Vibrations in Power-Transmitting Shaft*, due usually to high changes of stress on the shaft, combined with synchronizing forces and natural periods

Roughness experienced in automotive engines is usually due more to (1) and (2) than to (3). Synchronized torsional vibration, as defined in (3) can usually be avoided by the application of a small retarding force, either frictional or hydraulic, involving but little conversion of power into heat. The roughness of points (1) and (2) may come from so great a change of stress that it cannot practically be taken care of by damping absorption of energy, as in a frictional damper; rather, it requires a means of *storing* the driving energy at the high-pressure peaks and *returning* it later to the drive at a retarded rate, and this, it seems, is the essential improvement involved in the damper of Fig. 4. Obviously, such a device can be made to do much more than any frictional or hydraulic damper in which no restitution of energy occurs, since with these latter the effect is limited by the amount of energy dissipation which can be tolerated.

[15] M.S.A.E.—Engineer, Bendix Research Corp., East Orange, N. J.

# Some Primary Causes of Automobile Accidents

Northern California Section Paper

By Victor W. Killick

CAREFUL analysis of reports and open-minded investigation among drivers who had been involved in serious traffic accidents showed that the usual accident report seldom if ever reveals the primary cause and that the largest groups of accidents are collisions that occur at highway intersections and railroad crossings. The primary cause of these collisions was found to be the obstruction of the drivers' vision by the left front body-pillar or windshield corner-post and by narrow side and rear windows. Height of the side window from the floor and low front seats were also found to be important contributing factors.

The light switch on top of the steering-wheel was the definite cause of thousands of accidents through the headlights being accidentally switched off by the catching of the driver's sleeve in the switch when making a turn.

High speed, in excess of the State allowable maximum of 40 m.p.h., is asserted to be always dangerous. The mind requires an appreciable time in which to function and to cause the muscles to react, and the braking and steering mechanism of the car, even when in the most efficient condition, does not function instantaneously. At 80 m.p.h. split seconds become so important that life may hang upon a successful manipulation within 1/100 sec. Therefore speed is a dominant factor in deaths by motor-vehicle.

Engineers, concludes the author, should give first consideration to the driver's easy vision of the road ahead and to the sides.

MORE THAN 41,000 traffic accident reports passed through the Bureau of Research, Statistics and Traffic Safety of the California Highway Patrol in the year 1930. I personally read several thousand of these and carried on correspondence with hundreds of persons involved. I went into the field and talked with many traffic officers, not only those of the State but also the officers of the city police departments. I inspected more than 100 wrecked cars and was present at the scene of more than a dozen accidents when they happened. In addition, the State sent me on a tour of inspection through 22 other States in the summer of 1930 to compare the California situation with the conditions obtaining in those States and to gather the most effective accident-control ideas now in practice.

With all this opportunity to study the traffic-accident problem at first hand, I do not think I know all about it. Furthermore, I do not believe that any person in the State knows all about it.

### Highway Safety an Evolutionary Problem

An evolution in the nature of traffic accidents and in the causes of them is continually going on. Variations in population density, increases in motor-vehicle registration density, the types of highway construction, the development of safety devices and the design of motor-vehicles all have marked influences on the nature and causes of traffic accidents. Mention should also be made of another more intangible factor, but nevertheless an important one. This let us call the "community intelligence quotient," for want of a better name. By it is meant the relative intelligence of the mass of the population.

Our ability to measure directly the influences of each of these variables contributing to the accident situation seems always to have been a step behind. Not until we overtake these variables by more accurately forecasting or anticipating shall we be really qualified to plan and execute the remedies. Heretofore the tendency has been to plan and execute remedies prematurely. For that reason many of the so-called remedies have fallen discouragingly far short of full success.

Groups of high-minded men of experience have gathered around the board to discuss the traffic problem, tried nobly to visualize that situation and advanced ingenious schemes and suggestions to reduce the toll of life and injuries; but too frequently such understanding and remedies have been too academic to be fully practical. Many leaders of such movements have been thoroughly familiar with certain phases of the problem but not with the entire problem. The tendency under such circumstances is to overemphasize the importance of the angle with which one is most familiar, which invariably leads to inaccurate conclusions and imperfect remedies.

When more than a year ago I took the office of statistician of the Division of Motor Vehicles and the California Highway Patrol, I tried to assume the attitude that I knew nothing whatever about the traffic problem so that I would not view the facts as they came in with any preconceived prejudices. I had not been long on the job when a number of "experts" began to impress me with their thoughts and remedies. After listening to many, the outstanding observation was that seldom, if ever, did any two completely agree on the solution advanced. I tried to shield myself from this influence but found this hard to do, as some advanced their ideas forcefully and convincingly, and one could easily be led astray by the force of their convictions.

Real work started by making a tour of the State and

[1] Statistician, Division of Motor-Vehicles and California Highway Patrol, Sacramento, Calif.

making contacts directly with officers of the Highway Patrol, who actually had to meet the problem on the highways. In these contacts the discovery was made that all traffic officers agreed on a number of points and the majority agreed on others. From this as a basis, a new system for obtaining information on accidents was designed.

A system of field research was inaugurated to verify a number of theories and to observe the actual occurrences in a definite way. In these studies certain specially selected officers, operating in different localities, were instructed to make special reports on each accident in addition to the regular reports normally required. Some of these officers took a keen scientific interest in the research work, supplementing their very illuminating written observations with photographs, accurate measurements and contributing data.

One result of these field researches brought forth the conclusion that seldom, if ever, does the ordinary accident report reveal the *primary cause* of an accident. This discovery determined the use to which statistics should be put. Statistics should not be used to reveal the causes of traffic accidents, but they do serve to indicate the relative importance of certain groupings of accidents. Having exposed, for example, the most prevalent types, we have an indication in what direction to proceed with our detailed research studies.

### Causes of Intersection Accidents

As the statistics started to come in under our new system, it became clearly evident that the largest number of accidents involved collisions between two or more vehicles at a crossing intersection. For example, in 1930, out of 31,019 accidents on which a location report was obtained, 17,000 occurred at street intersections, 1100 at rural intersections, and 477 at railroad crossings. Thus, roughly 58 per cent of the accidents, and the largest individual group, happened at intersections. These statistics focused our attention on this particular phase of the problem.

Hundreds of officers were interrogated as to their explanation or opinion of the primary causes of such intersection accidents. Of a number of conditions that may contribute to causing an accident, one precedes all others. I wrote to or interviewed a number of drivers of motor-vehicles involved in these intersection accidents and from them obtained a realization that the basic or primary cause of many of these could be traced to a heretofore almost unsuspected matter. Frequently the primary cause of an accident is not the conspicuous matter that we first see in a study. Often it is an apparently insignificant or trivial matter that entirely escapes attention.

Victims of street-intersection accidents reported that they did not see the car which struck them, although they had been looking in the right direction. As the evidence began to accumulate, it forced the conviction that intersection accidents are almost entirely due to "clear vision" difficulties. For example, on checking a number of cases, we found a marked relationship between the size of the windshield corner-post and intersection accidents. Many of these accidents occurred to cars having a corner post with a diagonal of 5 in. or more across the horizontal section. A special technical study of this problem was undertaken, and I desire to point out some of the outstanding features of this matter.

### Front Body-Pillars Obstruct Vision

In checking 1000 motor-vehicles at random, the windshield corner-post was found to vary in dimensions from 1½ x 2 to 5 x 8 in., and the position of the driver's eyes to be normally about 24 in. from the post. All of these posts eclipse a portion of the driver's left-side view. The area eclipsed varies, generally, with the length of the diagonal of the cross-section of the post and the distance of the driver's eyes from the post. The blind area is of a triangular shape of which the position of the driver's eyes is the apex and the length of the base of this obscuring triangle increases with the length of the altitude of the triangle.

There is a tendency in the latest design of windshield corner-posts to flare out the base for artistic effect. Our conclusion is that this is not advisable. I might end this part of my criticism with a general conclusion: Let us accept the thought as a standing rule that the best practice for safety is to keep the size of the windshield corner-posts to the minimum that strength will permit and sacrifice artistic considerations to that end.

Another matter relating to intersection accidents came to our attention in the study of those particular accidents happening at intersections in which Stop and Go signals were installed. It was very puzzling to understand how, at an intersection so protected for pedestrians, a number of children were killed. A close examination of these accidents revealed that, in virtually every instance in which a child was so killed, the driver had absolutely failed to see the child standing or walking immediately in front of his car. This was particularly due to the fact that the driver's eye and attention were directed to the elevated Stop and Go signal and that, in such a case, if the driver's seat was set low, a child standing close in front of the car would not be visible. The tendency of the driver is to watch the signal, and, immediately upon seeing the Go sign flash, to step on the throttle and accelerate the car. The unseen child standing in front of the vehicle is thus knocked down and run over.

The low seat also makes it impossible for a driver to easily see the right-hand edge of the road. Quite a number of cars that have run off the right-hand side into the ditch have low front seats. A great many cars are designed with low front seats, particularly modern sport models. Standards of seat height should be developed if we are to approach better ideals in safe automobile design.

### Light Switches a Source of Accidents

A surprising number of letters from a large number of victims of automobile accidents that happened at night told of troubles they have had with the light switches on top of the steering column. While driving along the highway on a dark night and approaching a turn, the driver, in turning the steering-wheel, has frequently caught his coat sleeve in the sliding light-switch on the steering column and has inadvertently switched off the lights in the very act of making the turn. Traveling at a high rate of speed, cars have as a consequence run off the road and turned over or collided with objects.

The light switch on top of the steering column, as a feature of modern design, has definitely been responsible for several thousand accidents, injuries and death to riders in California during the last year. To avoid the difficulties mentioned, a light switch on the steering

column should be of the toggle variety. Light switches should also be of more positive action, in switching from bright to dim and vice versa. Courteous drivers have a tendency to dim the bright lights upon approaching a car coming in the opposite direction. As the change is made, a brief interval occurs during which the car has no lights. If the change requires pushing the light-switch lever through a quadrant to move from one contact to the other, a considerable amount of time elapses during which a rapidly moving car covers much ground and during which fatal consequences may ensue. If the switch is so made that, in breaking the bright-light contact, it can be pushed to and through the dim-light contact to, let us say, the parking-light contact, the fast-moving car may be without any driving lights at all. In this connection we should realize that a car moving at 40 m.p.h. is covering 58 2/3 ft. per sec.; and to consume a second or more in switching lights is easy.

While discussing lights, let us recall the many times we have been provoked while driving at night because of the so-called "one-eye" car approaching; that is, the car with one headlight. The trouble is that we never know whether it is the right or left-side light that is out and we cannot judge the amount of clearance to give. Also, we have all had a startling experience of driving at night along a road having dips and mounds. Our driving lights have been pointed directly into the ground when going down into the dip, then, on coming up out of the dip, they have pointed up into the air, so that we could not see far ahead. Without warning, as we roll along on the level again, we suddenly find a large truck, trailer or passenger-car immediately in front of us with the tail-light out.

On examining thousands of cars for faulty lights, it is found that many persons drive for weeks with only one headlight or with a tail-light out without knowing it. Let us put signal dash-lights in series with driving and tail-lights to warn the driver.

### Narrow, High Windows a Factor

Another feature in the design of some of our modern cars which certainly deserves a great amount of consideration is the narrow side and back windows. This particularly relates to modern coupés and sport-model cars. These narrow windows, especially where there is a large amount of solid body material forming the rear quarters of the car, tend to eclipse a driver's view to the rear as he looks out of the side of the car.

Three times as many accidents occur to drivers negotiating left-hand turns as to those negotiating right-hand turns. Often, in making a left-hand turn at an intersection, a driver may put out his hand in the proper way and look backward to some extent, but the angle of his clear vision is such that he cannot conveniently see very far backward and does not observe a rapidly approaching car following him. He starts to make the left-hand turn and is struck either on the left-hand side or in the rear by the approaching car, which he has totally failed to see at any time. This is the primary cause of a number of intersection accidents, and standards should certainly be set up defining safe dimensions for side and rear windows in all cars.

Attention should be directed also to the height of the side window from the floor of the car. One of the prevalent causes of accidents comes about through the giving of incorrect arm signals, or through failure to give any such signal at all. In cars which have window openings inconveniently high, the driver finds it difficult to put his arm outward for a signal. It has been found in a number of cases that a high window often compels a person, unconsciously, to give the right-hand-turn signal when he intends giving the left-hand-turn signal. Considerable physical effort is required to give an arm signal through a high window. Women drivers, whose arm muscles may not be well developed, have all they can do to turn the steering-wheel of a heavy sedan by the use of both hands. In view of these circumstances, we recommend that serious consideration be given to employing signaling devices, preferably of the mechanically actuated semaphore type, as part of the standard equipment of all motor-vehicles.

### Psychological and Mechanical Elements Involved

This discussion has so far been entirely confined to matters relating to clear vision. The question of clear vision is, in my opinion, the most fundamental factor of safe driving. It is the primary or initial element required before any of us can drive safely or cause safe mechanical action with our cars. We first must see. Designers of motor-vehicles should keep that thought uppermost in mind at all times. The matter of beautiful design should never be placed ahead of clear vision. Let me emphasize this in another way by presenting some of the psychological aspects of driving.

Contrary to the opinion of many who have not analyzed the situation, the human brain does not work instantaneously under any circumstances. For example, if one is driving down a highway and sees an object loom up in his pathway which he must avoid hitting, a complicated mental process must function over a period of time before it is possible actually to guide or control the vehicle.

Assume a normal case of a driver sitting with a passenger engaged in conversation but looking ahead and, upon turning a corner, seeing an obstacle 200 ft. away. His mental attention is engaged on the subject of conversation, and a fraction of a second is required to take his attention completely off that subject and focus it upon the business at hand. Another fraction of a second is needed for his mind to cause his muscles to react. Ordinarily, these mental functions are so rapid that most of us are unconscious of the fact that any time is consumed in their operation, but time has been consumed, although it is measured in terms of split seconds. More time is consumed in applying our muscular action to cause the relatively sluggish-moving mechanical parts of an inanimate car to respond. Perhaps the time required for the mechanical parts of the car to react to physical pressures may still be in terms of split seconds, but these fractional parts of seconds are of much longer duration than in the case of the mental actions. At this point the mechanical perfection of the car enters into the picture as a variable factor. If the braking mechanism is in perfect condition and the tensile strength in the parts to be stressed is sufficient, we get the maximum efficiency in the time required to operate. However, let so much as one part be in maladjustment and the period of time required to control the vehicle is materially lengthened.

Here again the question of clear vision is exceedingly important, because the avoidance of accidents depends, in almost every instance, upon the aggregate of the split seconds in the driver's operations.

### Distance-Time Relation at Speed

Most persons have absolutely no knowledge of the principles of mechanics involved in a traveling motor-vehicle. They receive as a piece of startling new information the statement that a car moving at the rate of 40 m.p.h., the legal speed limit of California, is covering the ground at 58 2/3 ft. per sec.

Consider, again, that the average passenger-car may weigh from 1 to 1½ tons, and visualize for a moment a projectile of this weight moving on the road at 58 2/3 ft. per sec. We then begin to realize something of the force embodied in the average motor-vehicle traveling on our roads. To further appreciate this power in simple terms, we may make the comparison that 374 hp. would be required to stop a 1½-ton vehicle moving at 40 m.p.h. within 1 ft. It is a power equivalent to that required to lift approximately 102 tons at a rate of 1 ft. per sec.

If the driver of a car, as previously mentioned, on seeing in his path an obstacle 200 ft. distant, requires, let us say, 1 sec. to take his mind off the subject of conversation, to cause his mental activities to produce muscular motion and act upon the mechanical parts of the car, he will have approached 58 2/3 ft. closer to the object he desires to avoid hitting. If, then, he applies his brakes and the mechanical parts of his car are in ideal condition, the velocity of the vehicle will begin to reduce, but it does not stop instantly. Perhaps, during the first second following the application of the brakes, the average speed of the vehicle is reduced from 40 to an average of 35 m.p.h. for the whole distance covered. At 35 m.p.h. the vehicle will have been passing over the ground at the rate of 51 2/3 ft per sec. Thus, at the end of these first 2 sec., the vehicle will be 110 1/3 ft. nearer the object that must be avoided, or less than 90 feet from it, which is fatally close. This driver will successfully avoid a collision only if all parts of his car are in perfect condition, which is an ideal that never is realized in practice. If he avoids a collision he will be a lucky favorite of chance and can claim no credit for expert ability as a driver.

### High Speed Always Unsafe

This example, relating to the operation of a vehicle within the present speed-limit provisions of the California Vehicle Act, illustrates that controlling a car traveling at 40 m.p.h. is a difficult technical matter at the best. Yet cars are traveling over our highways today at speeds in excess of this rate. A 50-mile rate is indulged in by many; a few take upon themselves the responsibility of driving at 60 m.p.h.; and recently one man made a boast to a State senator that he had safely traveled part of the road up the San Joaquin Valley at the rate of 80 m.p.h. When such high speeds are indulged in, the time element required in the control of a car is very much against the driver. The question of split seconds becomes so important and so delicate that life may hang upon a successful manipulation within 1/100 sec. Most of us are not constituted mentally or physically to respond to such requirements.

It is not a fact that the man who claimed to have driven on the California roads at 80 m.p.h. did so safely. He did so only at a tremendous risk, not only to himself but to others on the road. All high-speed driving is unsafe, a risk to the driver, a risk to the public and a risk to property.

Neither is it a fact that more accidents are caused by clumsy drivers moving at slow speed than by clever drivers traveling at high speed. When two cars come together moving at 20 m.p.h., fenders may be dented and passengers cut or scratched with flying pieces of broken glass, but seldom are the passengers killed in such a collision. When cars traveling at 40 m.p.h. come together, all passengers may be subjected to death. And when a collision occurs between cars traveling at higher rates of speed than the 40-m.p.h. legal rate in California, death is almost inevitable for one or more of the passengers. Our motor-vehicles and highways are not constituted to preserve life when rushing over the road at 80 m.p.h. How is it possible for an otherwise intelligent citizen to claim that he can safely drive a bounding, unstable motor-vehicle at such a speed on an open highway that is crowded with hazards at every mile?

### Car Designers' and Builders' Responsibility

I wish that we could adequately present the picture of the speed situation before our motoring public, together with a picture of how and why motor-vehicle accidents happen. If that could be done, buyers would demand a different type of automobile. The public would not buy cars because of their high power or their beauty alone; rather, they would first look to those elements incorporated in the construction of a car that would provide the maximum of safety protection. The public needs all the safety that car manufacturers can supply. But to educate a cosmopolitan people on such a technical matter is difficult. Therefore, I believe that the responsibility is upon the designers of motor-vehicles, first, and then on the producers, to initiate new standards of safety. In the near future more of the distributers of motor-vehicles will make their sales talks, not so much upon the high power of the car or its beautiful design, as upon those features that make for safety and protection of the owner.

To the engineers who have it within their power to shape and build the motor-vehicle, I cannot emphasize too much the importance of giving first consideration to the driver's easy vision of the road. Clear vision means the saving of precious seconds and split seconds in an emergency. It is a delicate matter in which is wrapped up a tremendous amount of safety significance.

# Heat-Treating Methods and Costs

Boston Metal Congress Paper

By Ernest Foster Davis[1]

DEVELOPMENT of continuous automatic methods for annealing, carburizing and hardening steel have made quality much more uniform than it could be when it depended upon the skill, attention and faithfulness of workmen. Modern furnaces carry out a scientifically planned cycle more accurately than workmen can, so that depth of case, for instance, can be held to close limits. The cost of the processes are greatly reduced; and far greater economies result from the increased uniformity of the product, which makes machining easier and reduces the number of defective parts. The choice between sources of heat should be made only on the basis of results.

Developments in forging are prophesied that will provide far greater accuracy than in present forgings and will eliminate scale.

PRESSURE of competition has compelled the engineer to lower the factor of safety; and the metallurgist, in turn, has been forced to eliminate, as much as he can, the variables which enter into the manufacture and heat-treatment of steel so that the parts will be safe and durable. Of all the metallurgical developments in recent years, none equals in importance the modern furnace. Without its aid, the application of the scientific principles of heat-treating to production manufacturing would be impossible. With its assistance, uncertainty as to the uniformity of physical qualities in steel has been largely overcome.

I honor the skilled heat-treater, but there can be no guarantee of uniformity in heat-treating results if one depends upon a group of workmen to perform the operations. Substituting a mechanical furnace, in which the elements of time and temperature are under sensitive control, and making such a furnace as automatic as is practicable eliminates not only the source of the variables but also the cost of maintaining the men who caused them.

Carburizing costs per pound have decreased from 10 to 0.9 cents in the last 10 years. With two men, our carburizing furnaces are producing an output that would require no less than 20 men by the old box-furnace practice.

Our present furnaces are of the return-recuperative type, in which the boxes are pushed automatically the length of the furnace, then laterally, on a car, to a second set of roller rails and a rear pusher which finally bring them out of the same door they enter. The outgoing boxes give up a portion of their heat to those entering, thus conserving a part of the heat. The boxes leave the furnace at about 700 deg. fahr. on the outside and 1100 deg. on the inside, while the actual carburizing temperature is 1700 deg. The British thermal units represented by these reductions in temperature are therefore retained in the furnace. The furnace is electrically heated and entirely automatic in operation. We have standardized cycles of pushing to yield 0.030, 0.040, 0.050 and 0.060-in. depths of case, which are held within 0.005-in. variation. The operators have nothing to do with these cycles or the temperatures; their duties are to provide a loaded box for each push and to unload the boxes as they cool. Provisions are also made for the mechanical mixing of the proper percentage of new carburizing material with the old. Suction fans remove the dust.

With this installation, we have no men adjusting burners and trying to hold a series of box furnaces at 1700 deg.; no trouble with heats going wild because of the failure of someone to observe the pyrometer dials; no such variations in carburizing depth as were common in box-furnace practice, in which it was not unusual for boxes in different parts of the same furnace to show 75 to 125 deg. variation in temperature; no arduous work and hot, toiling laborers juggling pots in and out of furnaces and occasionally tipping them over; no trouble with case-spalling during grinding, because of excessively high carburizing temperatures and too much cementite on the outer layers of the cases; and very little trouble from soft spots. Carburizing boxes last longer, because they are not gripped by tongs while hot; gears are not returned because of thin case and short life; field troubles because of defective carburizing do not exist; and we have eliminated 18 men.

### Continuous Furnace Aids Uniformity

Our plant is engaged in manufacturing gears and free-wheeling units, and the annealing of steel is extremely important to us. The machining departments demand ease of cutting, to enable them to utilize fast feeds and speeds in producing blanks, and the gear-cutting division insists upon smooth tooth-finish. In nearly all types of gear steel, some phase in the microstructure gives the best machining qualities. Some of these microstructures are more or less fugitive and difficult to obtain, and carefully worked out heating and cooling cycles are required to arrest the treatment at the desired point.

To establish a heating and cooling curve with scientific precision is one thing and to make it work out correctly in furnaces disgorging nearly a ton of annealed forgings per hour is another. Without the continuous furnace under automatic control in the vital zones, such a process would be impossible when annealing is done in large quantities; but we can be sure, with gear forgings heated at a definite rate and cooled in correctly worked out decrements by passing through an elongated chamber at a fixed rate, that the correct microstructure, within the limits of steel uniformity, will result.

The continuous furnace has demonstrated that various heats of steel of similiar chemistry do not respond alike to standardized annealing methods and that the steel mills yet lack the ability to produce a consistently uniform product.

The economies afforded by continuous annealing are not principally in fuel saving or labor reduction, although these are both tangible items amounting to thousands of dollars per year. The big saving lies in faster machining feeds and speeds, lower tool costs, the reduction of rejections due to noisy gears, and general improvement in production conditions. We never are prostrated now by epidemics of gear trouble, which at one time became so bad that shipments were absolutely stopped. We still have gear trouble, and no doubt we

[1] Chief metallurgist, Warner Gear Co., Muncie, Ind.

always will, but the mystery on the hardening process has been solved, and we generally can locate our troubles quickly.

Not only in gear making but also in many other branches of industry have modern furnaces solved manufacturing difficulties. The continuous sheet-normalizing furnace has been of great economic value to the automotive industry by producing a uniform quality of sheet suitable for the deep-drawing operations necessary for the fenders and bodies of modern motor-cars. This process is similar to gear annealing in its requirements for exactitude, for definite cycles must be established to produce the correct microstructure and grain size to yield the maximum deep-drawing qualities.

Continuous furnaces for normalizing and annealing bars have made their appearance in the steel industry and are giving the consumer bars that are heat-treated to a degree of uniformity impossible in the older car-type furnaces.

Nearly all classes of automotive parts are now being heat-treated in continuous furnaces. We have V-hearth pusher furnaces for piston-pins and small shafts; alloy belt furnaces for bolts, screws, coil springs, rollers and bearing races; and huge pusher furnaces for hardening and tempering crankshafts, leaf springs and front and rear axles. I have witnessed the operation of one rear-axle heat-treating furnace whereby three different degrees of hardness were obtained at three different locations on the shaft by one passage through the furnace, each held within very close limits.

### Screw Feeds Regulate Timing

In our plant great stress is laid upon uniformity of hardening practice. The majority of our gears are hardened from cyanide in long, rectangular pots. Over the top of these pots we have two rotating screws upon which the work is hung by hooks, the work itself being submerged in the molten cyanide at about 1500 deg. fahr. These screws rotate slowly and in doing so advance the work the length of the cyanide pot, and the work cannot conveniently be removed until it has traversed the length of the screw. This assures that each gear will have exactly the same time in the cyanide. The temperature in this furnace is controlled automatically within 10 deg. plus or minus, a close control that is made possible only by the fact that the furnace is loaded with cold work only at stated intervals.

After the gears are removed from the cyanide, they are hung on a smiliar screw arrangement over the quenching tank, which also is rectangular. A hood over the bath makes removal of the gears from the quench impossible until they have traversed the length of the tank, which requires sufficient time to cool them completely. We have found in the past that removing gears from the tank while too hot was a frequent cause of insufficient hardness.

After quenching, the gears go through a series of washers and finally are hung on an overhead conveyor where they are automatically tempered in an electric salt-bath furnace. This furnace is also arranged so that the gears cannot be removed until they have completed their tempering cycle, which requires 38 min. in the bath.

The possibility of human error has been eliminated as much as possible, and the economies are incalculable. Before this installation was made in our production lines, we had one man operating two 30-in. cyaniding pots; now we have one man serving four 60-in. pots and producing four times as much work per hour. The real economy comes from the fact that we have had extremely low gear rejections and practically no returns from the field, and, except for the initial difficulties in getting started, there has been no interruption in the flow of production that could be attributed to hardening defects.

### Changes Due in Forging Practice

Much remains to be done in furnace development, and the forging of steel is about due for an upheaval. Mighty presses are being built of such rigidity that nearly perfect forgings are the probable outcome. If the problem of scale can be solved, and I have reason to believe that it can, to produce forgings of an accuracy within a few thousandths of an inch will be easy. One company is working on a type of furnace which will heat steel to 2200 deg. fahr. without the formation of scale on the surface; and I have heated, forged and annealed 0.50-per-cent-chrome steel to a lamellor pearlitic structure without a particle of scale being formed during the entire process. But no progress can be attained with forge furnaces of the present types and the methods now used in forging plants. Furnaces will be designed to accomplish these results; but the process, which is revolutionary, has not yet been adopted, to my knowledge.

Another new development, which is just around the corner, is the continuous furnace utilizing gas as the carburizing medium. Estimates show that carburizing can be done in this way at about 0.6 cent per lb. and the character of the carburizing gas be maintained in the correct CO and $CO_2$ ratio. R. J. Cowan, metallurgist of the Surface Combustion Co., read a paper on this method before the Institute of Mining and Metallurgical Engineers[2], in September.

The means for heating a furnace should be based on metallurgical considerations only rather than on comparative costs per British thermal unit. If the latter item were paramount, coal would always be the logical means to employ, for it is the cheapest in initial cost. Our plants are in an area where 1000-British-thermal-unit natural gas is low priced; but our largest and smallest furnaces are electrically heated, while our intermediate sizes are gas fired, and there is a defintie reason for each of these selections. Relative fuel-cost does not enter to any great extent into our calculations of furnace economies.

### Quality of Heat Counts, Not Source

The use of electric heat is no assurance that the furnace will be heated more uniformly than with gas or oil; I have seen good and bad examples of all three types. I was recently in a brass-rolling mill where electric furnaces had been abandoned in favor of gas furnaces for annealing brass and non-ferrous-alloy strip because the gas furnaces showed more uniformity, and I have been in other plants where the reverse was true. A well-designed gas furnace is certainly better than a poorly designed electric one, and vice versa. I have observed types of electric furnace, particularly the rotary designs, which would not harden carburized work without soft spots, and I have seen other types that were nearly ideal in the results attained. Furnace design and the proper application of heat are therefore important factors in any installation, and they vitally affect the economies of operation.

The continuous furnace is not for the small job-shop with a wide diversity of product, but it is ideal for various industries specializing in the manufacture of automotive parts, whose output is more or less standardized and whose production quantity justifies the expenditure. These furnaces, as their name implies, are economical to operate only when they are in continuous service. It costs $30 to bring our gas-fired annealing-furnace up to operating temperature and $60 to bring our electric carburizing-furnace from cold to 1700 deg. fahr. Smaller continuous units are available which

(*Concluded on p. 478*)

[2] See Technical Publication 439, C79.

# The Turbo Supercharger

## Discussion of the A. L. Berger and Opie Chenoweth Paper at the 20th National Aeronautic Meeting

SANFORD A. MOSS[2]:—As the engineer who has had much to do with the construction of the turbo supercharger itself, I can pay tribute to the authors of the paper and their associates of the Army Air Corps. The paper does not exaggerate the difficulties that have been encountered in the development. The executive staff, engineers and pilots have shown remarkable courage and engineering ability in bringing the development to its present state. The authors of the paper and the present staff of the Engineering Section at Wright Field have contributed considerably. I would also like to pay tribute to the late E. T. Jones, formerly chief engineer of the powerplant branch of the Army Air Corps.

### What Has Been and What Remains To Be Accomplished

The theory of centrifugal compressors and steam turbines is known well enough to enable highly efficient designs to be made for stationary purposes. The application of all of this knowledge to the design of a complete powerplant of about 100 hp., having a total weight of less than 90 lb. and operating the turbine at 25,000 r.p.m. with buckets that are red hot, of course, leaves many problems to be solved. One of the turbine buckets weighs about 0.01 lb., but the centrifugal force of a bucket at full speed is 70,000 times this. That very few failures of the supercharger itself have occurred is a matter of pride. The bucket trouble which has been encountered, as described in the paper, was due to the temperatures at which the buckets operated and the material used in the early work. Except for this, very little difficulty has been experienced with the operation of the supercharger itself. Of course, the early work had to be concentrated on getting the complete system of airplane, engine and supercharger to operate. Recently some progress has been made in improvement of the efficiency of the turbine and compressor themselves. This work is still in progress and more improvements will follow.

In the early use of the turbo supercharger on Army airplanes, quick acceleration was lacking. That this disability is wholly removed, due to use of the automatic control and the method of manipulating the supercharger speed, is a matter of congratulation.

The authors of the paper pay but slight attention to the suction-type carbureter which has been used successfully with geared superchargers. This, I believe, offers good possibilities for future experimental work.

This entire paper applies only to the use of the turbo supercharger for military purposes. The results shown indicate that the turbo supercharger has possibilities for commercial use, in place of geared superchargers now used almost exclusively. Several efforts have been made to direct the attention of commercial transport companies to the turbo supercharger, and I hope that these efforts will eventually result in some installations.

THOMAS BARISH[3]:—How fast does the supercharger operate?

A. L. BERGER:—The maximum speed is approximately 23,000 r.p.m., but we have attained considerably higher speeds. Roughly, the increase is about 1000 r.p.m. for every 1000 ft. gained in altitude.

Dr. Moss was very considerate in remembering E. T. Jones, who was very instrumental in initiating the development of superchargers for the United States Government and carried on this work until he left the service of the Government. Very many of the studies mentioned in the paper were made under his direction.

### Partial Supercharging and Exhaust-Gas Temperatures

BROOKS WALKER[4]:—Has any experimenting been done on supercharging an engine in which only a normal portion of the intake charge enters the cylinder by the ordinary induction caused by the piston action and the rest of the charge is supplied by supercharging through a small port in the base of the cylinder, which is opened by the piston at the end of the stroke? A gain in efficiency is effected by this method, because the ordinary induction is more efficient than the supercharger, and a relatively small supercharger will amply supply a large engine.

What is the increase in the exhaust temperature with supercharging? Some superchargers were tested in California, where the supercharge was 20-lb. gage, without causing any appreciable increase in exhaust temperature.

MR. BERGER:—I do not know whether attempts have been made elsewhere to supercharge only a part of the charge, but no such work has been done by the Air Corps.

O. CHENOWETH:—Exhaust-gas temperature is controllable to some extent in airplanes, although it might not be in other applications. Undoubtedly the exhaust gases are appreciably cooled by their transfer across the front of the engine and through the exhaust pipes. If, however, these pipes were insulated, the temperature might be increased considerably without any thermodynamic change in the engine caused by the application of the supercharger.

### Suction-Type Carbureters

Dr. Moss's statement on suction-type carbureters being more adaptable to supercharger use is open to some question when the engine-supercharger combination is considered. Certainly a suction-type carbureter does give lower intake temperatures to the supercharger itself, but, thus far, on a number of our engine tests, we have found that the fuel-air mixture could not be satisfactorily distributed to the cylinders under all conditions.

Many of the later designs that formerly used the suction type of carbureter show a tendency toward the pressure type with the more-efficient manifold so far as distribution is concerned. Considering the super-

(*Concluded on p.* 478)

[1] The paper was published in the S.A.E. JOURNAL for October, p. 280. Both authors are connected with the engineering section, Materiel Division, Air Corps, Wright Field, Dayton, Ohio. Mr. Berger is engineer in charge of supercharger development and Mr. Chenoweth, who is a Member of the Society, is engineer in charge of development and test.

[2] Mechanical engineer, Thomson Research Laboratory, General Electric Co., West Lynn, Mass.

[3] Assistant chief engineer, Gurney division, Marlin-Rockwell Corp., Jamestown, N. Y.

[4] Chief engineer and owner, Walker Pavecar, Piedmont, Calif.

# A Study of Airplane and Instrument-Board Vibration

## Discussion of Stephen J. Zand's 20th Aeronautic Meeting Paper[1]

C. H. DOLAN[2]:—Would a company be allowed the use of one of your vibrographs?

S. J. ZAND:—Certainly. We will gladly arrange to make any number of tests that may be required to solve some particular vibration problem. We do not purpose, however, to go into an extensive production schedule on the vibrograph. We shall make a few for Government agencies or anybody who is particularly interested in vibration problems. We think that it will be more advantageous for us as well as for airplane manufacturers to lend the instrument and have the interpreting of records done by us, as this requires a certain amount of training, especially to do it quickly.

MR. DOLAN:—We have under construction now about 22 instrument-boards which we are mounting on rubber, using a device which comprises a small piston with sponge-rubber washers on both sides. The instrument-board is free to "ride"; it has one device on each side and one on the bottom. In this way we have secured wonderfully good damping effects. Recently, after a pilot crashed, the clock was still running and no glass on the instrument-board was broken.

MR. ZAND:—Shock-absorbing mountings were not mentioned in the paper, but this was done purposely because rubber or other devices applied at the instrument-board may reduce vibration materially, but the improvement will be only local; that is, at the instrument-board only. But if the problem is attacked in a broader way by trying to eliminate vibration at the source, as indicated in the paper, the improvement will be general and probably very beneficial to the whole structure.

A word of caution is needed regarding the flexible mounting. First, it should be borne in mind that the elasticity of rubber is a variable value depending upon many factors such as initial tension, quality of rubber stock, time of curing, humidity, temperature and age. Therefore I fear it may happen that, after a certain unknown period of time, the rubber or any other material will deteriorate or change its characteristics in such a way that vibration at the instrument-board will be increased instead of decreased. Second, if we make a "riding" instrument-board, we must watch out for trouble in the many tube connections leading from the instrument-board to the respective connections at the engine, venturi, and the pitot static tubes.

Yet, while I do not like the idea of elastic suspension, I do not want to be taken too authoritatively, as I have tested only 16 different types of airplanes. While some conclusions are fairly good, one cannot depend upon them entirely. I should like to test at least 100 to 150 airplanes and then redraw my conclusions. They might change materially.

S. A. MOSS[3]:—Does the instrument-board move back and forth with the plane, or does it vibrate itself?

MR. ZAND:—So far as we could ascertain, it vibrates with the engine frequency, and it can therefore be presumed that the structure near it also vibrates with the engine frequency. For example, if one flies with the engine throttled down to 1400 r.p.m., the board will vibrate at 1400 cycles per min.

MR. MOSS:—It does not vibrate at its own frequency?

MR. ZAND:—No, unless it is located very far away from the engine; then it will vibrate with its own natural frequency. I had the instrument-board on one plane mounted 9 ft. from the engine. There, the board vibrated at about 1600 cycles per min., no matter what the engine speed was. If the board is moved forward, the forced vibration seems to be much larger than the natural one and the board will vibrate with the engine frequency.

MR. MOSS:—Could you not stiffen the instrument-board?

MR. ZAND:—No. Stiffening might introduce some effects that would enter into the resonant range; then, instead of decreasing vibration, one would increase it.

### Calculation of Vibration Period Is Difficult

K. D. WOOD[4]:—Have you had any trouble in calculating the period of vibration in some of the structures?

MR. ZAND:—Yes, often; but the difficulties related to the calculation of the natural periods of structural members are so interesting from a mathematical standpoint that I think one can derive a great deal of satisfaction from trying to solve such problems. The procedure is always the same and is clearly indicated in the paper as well as in many text books, particularly in S. Timeshenko's monumental work entitled, Vibration Problems in Engineering, cited in the paper. When the structure is simple, the calculation leads to a differential equation which in most cases can be integrated. However, if the structure is complicated and lying in more than one plane, the problem often becomes beyond the mathematical equipment of the engineer. I solved a few such equations, but the amount of work was out of proportion to the results thus obtained. One of the main difficulties is the transformation of the differential equations into, so to speak, a "classical" form, or a form which can be fully integrated. Unless this is possible, only an approximate graphical or analytical solution is possible. Further, constants of integration can be evaluated only for selected conditions, and sometimes those conditions are not the ones which interest us; but it is worth trying.

MR. WOOD:—Have you made any experiments with geared engines?

MR. ZAND:—No; but I intend to make such tests.

PROF. VOLNEY C. FINCH[5]:—Were any of the tests made on planes having the old stick-and-wire construction and a wooden fuselage?

MR. ZAND:—No, they were all made on modern airplanes. We made tests on the latest Navy and commercial models. Most of the tests were repeated several times and average results were used for plotting the

---

[1] The paper was published in the S.A.E. JOURNAL, October, 1931, p. 263. Mr. Zand is a member of the Society and aeronautical engineer for the Pioneer Instrument Co., Inc., division of the Bendix Aviation Corp., Brooklyn, N. Y.

[2] M.S.A.E.—Assistant operation manager, Eastern Air Transport, Inc., Brooklyn, N. Y.

[3] Thompson Research Laboratories, General Electric Co., Lynn, Mass.

[4] Assistant professor, Cornell University, Ithaca.

[5] M.S.A.E.—Professor of aeronautical engineering, Alabama Polytechnic Institute, Auburn, Ala.

curves, so as to eliminate any possibility of error of interpretation of records.

MR. DOLAN:—Is there a period of sympathetic vibration of the fuselage with the period of the engine that might have a tendency to increase vibration?

MR. ZAND:—Yes, it may happen if the natural period of the fuselage is somewhere near the operating range of the engine.

### Noise Reduction Being Studied

MR. DOLAN:—On one plane I installed double glass all through the cabin to dampen vibration noise in the cabin. This reduced the noise considerably. I had thought that the air space between the two panes of glass might deaden the noise caused. I have always had the impression that sympathetic vibration exists in many fuselages.

[5] S.M.S.A.E.—Engineer in charge, for the National Advisory Committee for Aeronautics, Hampton, Va.

MR. ZAND:—Work is in progress on decreasing noise and vibration. It is being done by the National Advisory Committee for Aeronautics.

HENRY J. E. REID[6]:—We have nothing to report on that investigation as yet. It is a difficult investigation, but we are carrying it on, and I hope that we can secure some valuable information soon.

MR. MOSS:—Why does engine vibration, which is in the plane perpendicular to the axis, make the instrument-board vibrate otherwise than in the plane perpendicular to the axis?

MR. ZAND:—Any force can be resolved into three components, and as the least moment of inertia of an instrument-board is perpendicular to the longitudinal axis of the airplane, the fore-and-aft component will cause the greatest damage, acting on the weakest part. While the other components are present, they cannot affect the board very much because it is too stiff along the two other axes.

## Heat-Treating Methods and Costs

(*Concluded from p. 475*)

might be practicable for the smaller plants having diversified or intermittent production, but even these units require the assurance of volume to make them profitable.

However, the smaller plant does not have the production problems of the larger. Mistakes must not be made and troubles must not occur in the larger plants, because anything that lowers the quality affects such a large quantity of product and anything that interrupts the smooth flow of production is exceedingly costly.

Much credit is due to the furnace engineers who have developed the efficient equipment of today. They have had to take sporting chances many times, when unusual problems have been presented, by guaranteeing successful operation. They have sometimes lost and lost heavily, and they have usually charged off their losses in good grace. Many a furnace is in successful operation today which was a failure in its original design and cost the furnace company many thousands of dollars more than he charged for it, but I have found these engineers bold and progressive and real pioneers in the practical phases of metallurgy.

Credit is also due to the instrument and fuel-control makers, who have provided the sensitive nerve systems for these mechanical robots that do their work more efficiently and cheaply than can the human.

## The Turbo Supercharger

(*Concluded from p. 476*)

charger only, using the suction carbureter is an advantage, but, when the final performance of the engine is considered, it is still open to considerable question. All indications are that the pressure-type carbureter is much more satisfactory.

CHAIRMAN PHILIP B. TAYLOR[5]:—Another type of exhaust-driven supercharger in which the exhaust gases are passed through ejector nozzles, thus converting all pressure into kinetic energy, has been suggested. The exhaust gases, moving at high speed, then pass through the turbine, where the kinetic energy is converted into work. This, on a theoretical basis, results in an increased efficiency but is a difficult application, because the exhaust ports are fixed in the installation and the turbine must be close to the exhaust port to prevent loss of energy through wire-drawing. In other words, the supercharger must be centrally located in relation to the exhaust ports, which involves many installation problems.

MR. BARISH:—A striking resemblance exists between the present development of the turbo supercharger and the Lorenzen gas turbine[6] built in Germany. I wonder how much of their experience in the metallurgical problems might be useful here. The two look almost exactly the same as they stand now.

MR. BERGER:—The work mentioned by Mr. Barish was for the purpose of developing a gas turbine. No doubt all of this work was reviewed by the very early investigators of turbo superchargers.

CHAIRMAN TAYLOR:—I was interested in the iron-base alloy mentioned in the paper, as it seems to cover a multitude of sins.

MR. BERGER:—The turbine buckets now in use are very satisfactory, but I am not at liberty to state the analysis of the material.

[5] M.S.A.E.—Chief engineer, Wright Aeronautical Corp., Paterson, N. J.

[6] See *Mechanical Engineering*, March, 1929, p. 220.

Automotive Research

# Graphical Determinations of Streamline Curves

THE EMPIRICAL METHOD herein described by Albert Voegeli[1] gives a streamline form that is very nearly the same as the streamline form now in use and it should be of interest and helpfulness to some designers and most draftsmen. Ralph Upson, designer of the metalclad airship ZMC-2, states that he has had his greatest success in adhering to the principle of having no sharp breaks in the curvature anywhere near the maximum section and that the type of section herein suggested meets this condition only for one length of nose; namely, when it is 39 per cent of the total length. This proportion is obtained when the spaces along the axis of the tail are made equal to the length of arc into which the larger circle is divided. In his paper, Wings—A Coordinated System of Basic Design,[2] Mr. Upson gave simple equations by which the draftsman can plot any desired nose-to-length ratio while maintaining the principle of a continuously curved profile. However, Mr. Voegeli's graphical method is quick and easy to apply.

THE DEVELOPMENT of streamline curves always has presented a problem of some difficulty to the usual draftsman. The form of the nose and that of the tail end of a fuselage, the tail surfaces, nacelle cowling, landing gear and wheel fairing has depended to a considerable extent upon the skill and artistic ability of the designer. Many able draftsmen lack knowledge of the existing but elaborate method used by the well-informed designer to determine the contours of an efficient streamline by careful computations based on percentage of width to length. A graphical solution that is accurate, uniform and that if used once can easily be remembered, is offered herein to those who are entrusted with the designing of streamline bodies.

The endeavor of airplane manufacturers today is to produce an aircraft having the maximum aerodynamic efficiency that will make it capable of flying at a speed of 350 to 400 m.p.h. with the minimum expenditure of power. To reduce the parasite drag, a correct and uniform streamline shape is of prime significance for either new projects or less efficient existing airplanes. Consequently, more draftsmen will be required to know a simple method that will help them to meet problems of fairing and the like with speed and accuracy.

Selection of fineness ratios for various air-speeds and purposes, such as fairings or tail surfaces, depends largely upon the requirements of the particular airplane for which they are to be designed to give the maximum performance. Fairings, in general, have a fineness ratio of 2.5 at 100 m.p.h., 3.0 at 150 to 200 m.p.h. and 3.5 above 200 m.p.h. Fineness ratios for 350 to 400 m.p.h. must be computed more accurately and tried extensively in flight for efficiency so that the addition of weight shall not offset the gain in reduction of drag.

Fineness ratios for tail surfaces usually are determined by the structural properties of the design. Supported or braced tail surfaces have a thickness of 5 to 7 per cent of their maximum chord length, while cantilever tail surfaces have a thickness of as much as 7 to 9 per cent of their chord length.

The nose of a fairing is 30 to 35 per cent of the total chord length, while the nose of a streamlined tail surface varies from 30 to 40 per cent.

When the dimensions of a fairing or tail surface have been found; that is, when the width, chord and nose dimensions are determined, the development of the streamline can be started by constructing the major axis $X$ and the minor axis $Y$. (See Fig. 1.) Then, from the intersection $O$ of the axes, strike circles with the radii $R$ and $R_1$, which represent respectively the limits of the minor and the major axes of the nose. Divide $R_1$ into equal segments 1, 2, 3 and so on and construct rays from the point $O$ to cut the circles $R$ and $R_1$ at $1_1$, $2_1$, $3_1$ and so on and at 1, 2, 3 and so on. From the intersection of these rays with circle $R$ draw lines parallel with axis $X$, and from the intersections with the circle $R_1$ draw vertical lines to meet the horizontal lines. The intersections of the horizontal and vertical lines give points in the outline of the nose curve, and when these points are connected by means of smooth curves the contour of the nose is obtained.

The tail-end curve can easily be constructed by the following process: The chord length and the nose dimensions being known, measure the length of the tail from axis $X$ on axis $Y$. Divide this length into as many equal portions as there are segments in the quadrant $XY$ and circle $R$. Then draw verticals $1_2$, $2_2$, $3_2$ and so on to intersect horizontals from $1_1$, $2_1$, $3_1$ and so forth on circle $R$. The points where the horizontals meet the corresponding verticals determine the contour of the tail end.

Obviously, the greater the number of segments there are in circle $R$, the more accurate will the contour of the streamline become. For simplicity the constructing lines on the lower side of Fig. 1 have been omitted, but in practice lines similar to those on the upper side should be used for dimensioning the streamline shape.

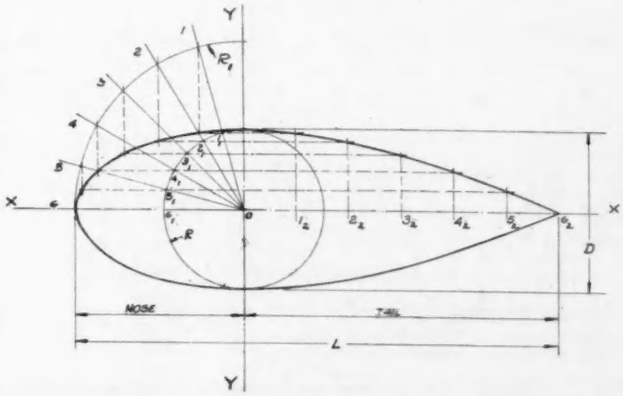



FIG. 1—DIAGRAM OF GRAPHICAL METHOD OF DETERMINING ACCURATE AND UNIFORM STREAMLINE CURVES

[1] M.S.A.E.—Aeronautic engineer, Consolidated Aircraft Corp., Buffalo.

[2] See S.A.E. JOURNAL, January, 1930, p. 15.

# Standardization Progress

## New Physical-Property Charts

### *Iron and Steel Division Develops New Curves for S.A.E. Steels Nos. 3130 and 6130*

ONE OF the most valuable features of the S.A.E. Iron and Steel Specifications since their original adoption in 1912 has been the physical-property charts for the various types of steel, indicating what normal minimum properties may be expected by normal heat-treatment of those steels.

Several years ago the original heat-treatment charts were carefully reviewed by the Division and modernized in keeping with the developments made in the steels and their heat-treating. Up to about that time this work was regarded as being almost entirely in the province of the metallurgist but now it is more generally realized that the development and most effective use of these specifications is as much a function of the designing engineer using steels as it is of the metallurgist. This realization has been brought about through the use of more greatly stressed parts of reduced weight, better wear-resisting characteristics and more skillful designing to prevent failures after machining. The metallurgist must supply the designing engineer with reliable data as to what may be expected of various steels, and the designing engineer must furnish to the metallurgist complete information as to what he expects from the materials that the metallurgist can make available.

Realization of the mutual responsibility of the metallurgist and designing engineer led the Division more than five years ago to start a careful study of physical properties. A subdivision of which T. H. Wickenden, of the International Nickel Co., is Chairman, conducted a long series of tests with the invaluable cooperation of 28 other companies. From these tests E. J. Janitzky, of the Illinois Steel Co., developed frequency or probability curves rather than straightline curves of averages alone, as it was believed necessary to express the results in a range limited by minimum and maximum values within which users of the charts might expect to obtain satisfactory results.

The project was largely in the nature of a development program and, because of the great amount of laboratory work that was necessary, the tests were restricted to characteristic S.A.E. Steels Nos. 3130 and 6130. The results of the tests on Steel No. 6130 were published[1] four years ago.

The same procedure was then followed with Steel No. 3130, with the results described briefly herein, so as to establish a basis for comparison with the present S.A.E. physical-property curves.

The heat-treatment prescribed for tests of S.A.E. Steel No. 3130 was as follows on all samples that were 1-in. round stock:

(*a*) Heat to 1525 deg. fahr.
(*b*) Hold at temperature 15 min.
(*c*) Quench in clean cool water.

The bars were then drawn as follows: one set at 800 deg. fahr. for 1 hr.; the second set at 1000 deg. fahr. for 1 hr., and the third set at 1200 deg. fahr. for 1 hr. The specimens were then correctly machined to standard tensile bars and physical-property tests were made.

The probable minimum and maximum deviations from standard were

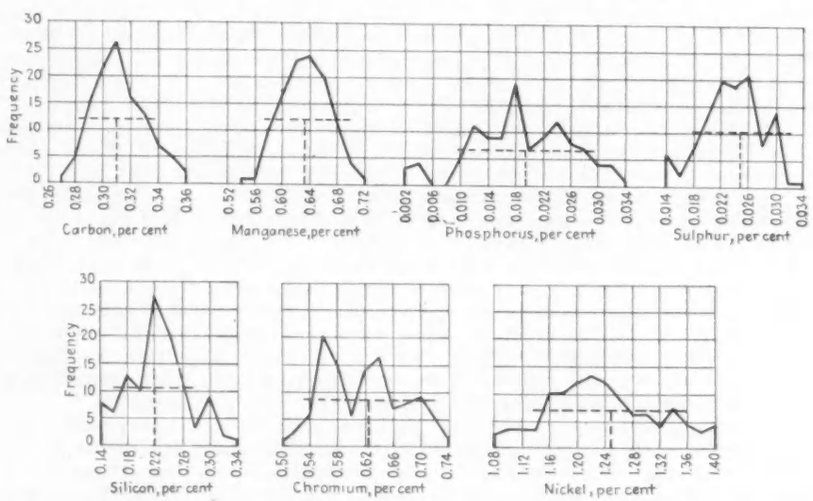



FIG. 1—FREQUENCY CHARTS OF CHEMICAL COMPONENTS OF 112 SAMPLES OF S.A.E. STEEL NO. 3130 USED IN THE TESTS

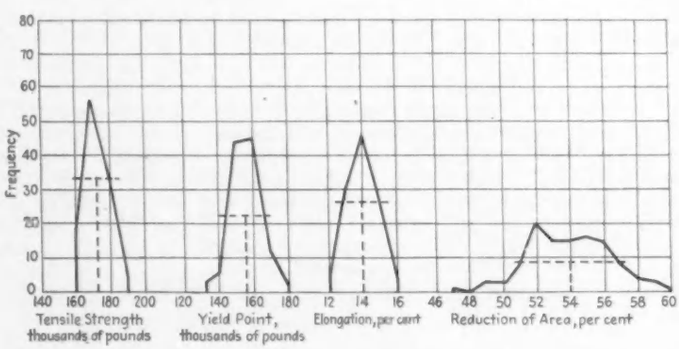



FIG. 2—FREQUENCY CHARTS OF PHYSICAL CHARACTERISTICS OF 112 SAMPLES OF S.A.E. STEEL USED IN TESTS
These Samples Were Drawn at 800 Deg. Fahr.

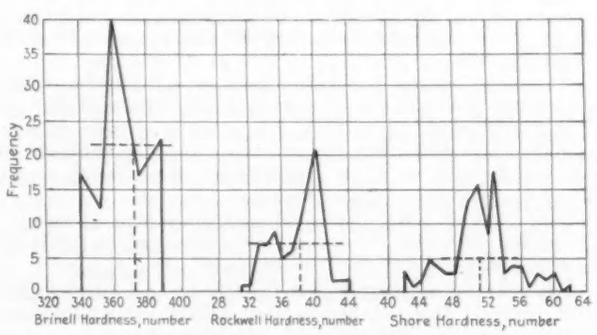



FIG. 3—FREQUENCY CHARTS OF HARDNESS TESTS ON 112 SAMPLES OF S.A.E. STEEL NO. 3130 DRAWN AT 800 DEG. FAHR.

[1] See S.A.E. JOURNAL, January, 1928, p. 55.

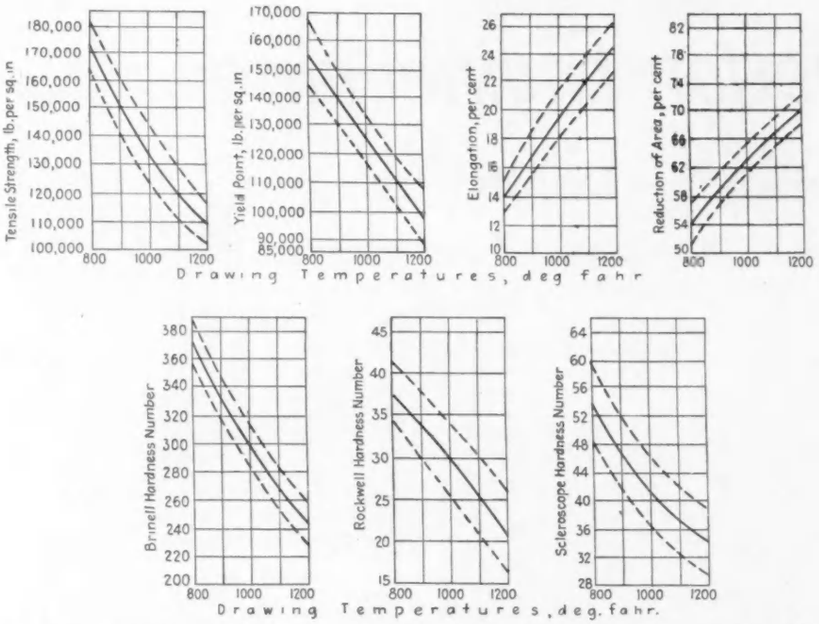

Tensile Strength, lb. per sq. in
Yield Point, lb. per sq. in
Elongation, per cent
Reduction of Area, per cent
Drawing Temperatures, deg fahr
Brinell Hardness Number
Rockwell Hardness Number
Scleroscope Hardness Number
Drawing Temperatures, deg. fahr.

FIG. 4—PROBABILITY CURVES OF PHYSICAL PROPERTIES OF S.A.E. STEEL NO. 3130
These Are Derived from the Frequency Charts of 112 Samples Tested

obtained for tensile strength, yield point, elongation, reduction of area and Brinell, Rockwell and scleroscope hardness by plotting the values reported as abscissas against the frequency of occurrence of each value as ordinates. The positive and negative standard deviations in each case were found by dividing the planimeter area under the curve by the length of the base on which the curve rests, the length being expressed in the same units as the area. This gave the height of a rectangle constructed on the same base and having the same area as that enclosed under the curve. The points at which the top of this rectangle cut the original curve indicate the positive and negative standard deviations from the mean. This mean is found by halving the range between the positive and negative standard deviation and erecting a vertical through that point intersecting the base. This range will denote the maximum and the minimum values.

The accompanying curves illustrate the erection of the frequency curves from which the physical-property curves were developed.

This outline of the study that has been made by the Division is published in this issue preliminary to a more complete report that is expected to be submitted to the Standards Committee and the Society for approval as an appendix to the physical-property charts in the S.A.E. HANDBOOK until such time as the Division feels that a new set of physical-property charts should and can be developed to replace those now published for the various groups of steels.

## Newton L. Reed

WITH MUCH REGRET the Crew Levick Co., of Philadelphia, reported the death on Oct. 4 of Newton L. Reed, who had been connected with the company for the last 11 years in charge of truck operation and maintenance.

Mr. Reed, who was admitted to Junior grade in the Society in 1923 and transferred to Member Grade in 1928, had an unusual career in industry. Born at East Canton, Ohio, in 1898, he received his technical education at the Michigan Agricultural College, specializing in chemical engineering in his fourth year and receiving the degree of Bachelor of Science in Chemical Engineering. Following post-graduate work in chemistry and metallurgy, Mr. Reed spent several months in research work for H. L. Doherty & Co., of Toledo, Ohio, in the design and operation of brass-melting and heat-treating furnaces. He joined the Crew Levick Co. in 1920 and for a number of months was engaged in sales and engineering work in no way connected with motor-vehicle equipment. In the latter part of the year he was made foreman of the motor-truck repair department, and in December was appointed superintendent of motor equipment. From that time on he devoted all of his attention to the company's fleet of trucks, which grew from 110 to 250 in 1928, operating in half a dozen States. He studied operating conditions in the field, the design and cost of operation of the trucks, installed a complete system of cost accounting, bought all needed vehicle equipment and supervised the operation and maintenance of the fleet.

Besides being a member of the Society, Mr. Reed was for a number of years a member of the American Chemical Society and in 1927 was appointed a member of the Transportation Committee of the American Petroleum Institute.

## Karl Dumas Chambers

AS A RESULT of illness that continued since last spring, Karl D. Chambers, engineer and director of Polarized Lights, Inc., of Newark, N. J., passed away on Oct. 8 at Oteen, N. C.

Mr. Chambers was elected to Associate membership in the Society in April, 1926, and at the Summer Meeting that year he presented a paper on Complementary-Color Headlighting which was published in THE JOURNAL for June, 1926, p. 613.

Born at Montgomery, Ala., in 1893, Mr. Chambers was graduated from the Sidney Lanier High School in 1911 and then studied the electrical engineering course at the University of Wisconsin. From 1915 to 1917 he was assistant superintendent of the efficiency department of the Cadillac Motor Car Co., of Detroit. Since 1923 he spent most of his time in research work directed toward the problem of automobile headlighting. After solving to his satisfaction the technical difficulties, he obtained patents in several countries on his system of lighting whereby glare is eliminated by means of color filters. He became the engineer and a director of Polarized Lights, Inc., in 1930.

## Conrad G. Dietz

IN THE SERVICE of aviation, to which he had contributed an indelible record in engineering, promotion and development, Conrad G. Dietz met his death in an airplane crash on Sept. 12. As nothing apparently was wrong with the airplane he was flying and he had flown airplanes for a number of years although he had not yet secured a pilot's license, it is believed that he lost consciousness momentarily while flying close to the ground and crashed before he or the plane effected a natural recovery.

Mr. Dietz, who was admitted to Member grade in the Society in May, 1931, was vice-president and general manager of the Aeronautical Corp. of America, of Cincinnati. He was only 31 years of age, having been born at Cincinnati in 1900. He attended the Asheville Preparatory School in Asheville, N. C., and was graduated from the Ohio Mechanics Institute in 1914. From May, 1920, to November, 1928, he was president of the Dietz Laboratory, of Dayton, Ohio, for which he had charge of all engineering and other work. In the latter year he joined the Aeronautical Corp. of America in the capacity of vice-president and general manager and had supervision of all the engineering work of the corporation and the development of the Aeronca light airplane.

# Production Engineering

## Gaging to 0.00001 In.

### *Electric Measuring-Device, Applicable to Production Gaging, Gives Multiplication of 10,000 to 1*

REFRIGERATORS manufactured by the General Electric Co. have all their working parts sealed in oil. As no service adjustments can be made, extreme accuracy is required. No way existed to make measurements of the required accuracy with the rapidity required for manufacture, so the electric gage was developed to meet the need. H. M. Gustafson, of the General Electric Co., in Seattle, read a paper about this gage at a recent meeting of the Northwest Section. The following description and illustrations are taken from Mr. Gustafson's paper.

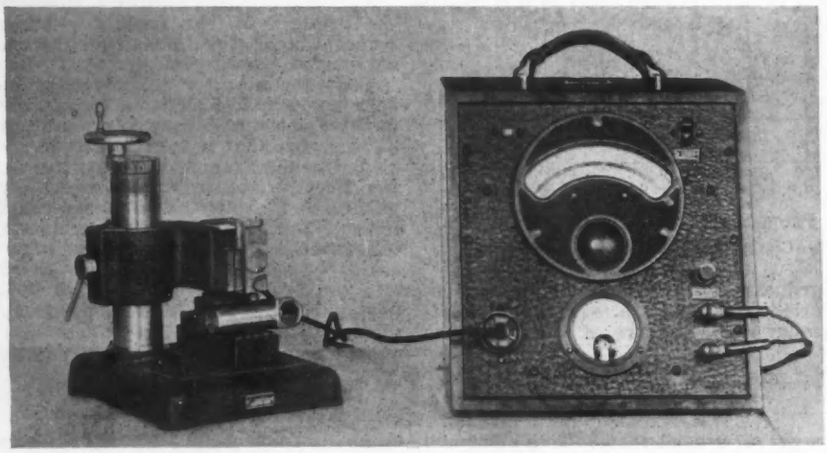


FIG. 1—ELECTRIC OUTSIDE-DIAMETER GAGE ON STAND, TOGETHER WITH INDICATING UNIT

The gage consists essentially of a contact point supported to move through a limited distance in the direction of measurement, say 0.005 in. This movement causes a pointer to travel a distance of 5 in. over the scale of an indicating instrument. Such magnification provides for easy factory inspection and control of manufactured parts within desired limits and exact measurement of small distances. Electric gages have been built with magnifications of 500, 1000 and 10,000, and magnification of 100,000 is possible.

Multiplication of movement is obtained by unbalancing an electric bridge-circuit of four inductances. A 500-cycle alternator supplies power to a small transformer, which in turn supplies power to the four inductances. Two of these small inductance coils are located in the electric-gage head, which has dimensions of $5 \times 2\frac{1}{2} \times 1\frac{1}{2}$ in. The inductance of these two coils is varied by the movement of a pivoted steel-lever armature, one end of which moves between the coils as the contact point on the other end conforms to the surface of the piece being measured. The contact point is in the electric-gage spindle, which is made to fit the work. The other two inductances of the bridge, together with the 500-cycle alternator, the transformer and indicating instrument, are mounted on an indicating unit, $12 \times 12 \times 12$ in. in dimensions, which is placed in easy view of the operator.

FIG. 2—GAGE FITTED FOR MEASURING PISTON-PIN HOLES

Both units are shown in Fig. 1, in which the diameter of a refrigerating-machine piston is being gaged. In gaging the crankpin hole in the same part, the piston is placed over a spindle and rotated once while the operator watches the pointer on the instrument. The limits of 0.7509 and 0.7512 in. are indicated by marks 3 in. apart on the scale. This gage passed 165,000 pistons in one year with no renewal or refinishing of parts, merely being cleaned several times. The ordinary paddle-type gage which this replaced had to be refinished after passing about 400 pistons. An internal gage arranged for the piston-pin holes in the piston and connecting-rod of an automobile engine is shown in Fig. 2, with two master rings.

Long life of the spindle of the electric gage has been obtained by the use of appropriate materials; the bearing surfaces which support the piece to make the measurement independent of the human touch are of Carboloy, and the contact point which explores the piece is of diamond. The contact pressures are sufficiently low that the material being gaged will not be scratched.

Three measurements are made simultaneously by the gage shown in Fig. 3 and are indicated on a triple-dial indicating unit. The dimensions are the outside diameters of the shaft and crankpin and the throw of the crank of the refrigerating-unit crankshaft that is shown in place.

Exploring the inside diameter of an automobile cylinder is the function of the gage seen in Fig. 4. Measurements can be made in any direction and at any distance from the head and are indicated on the dial unit.

The device shown in Fig. 5, known as the photo-electric recorder, will give a record of the measurements made by

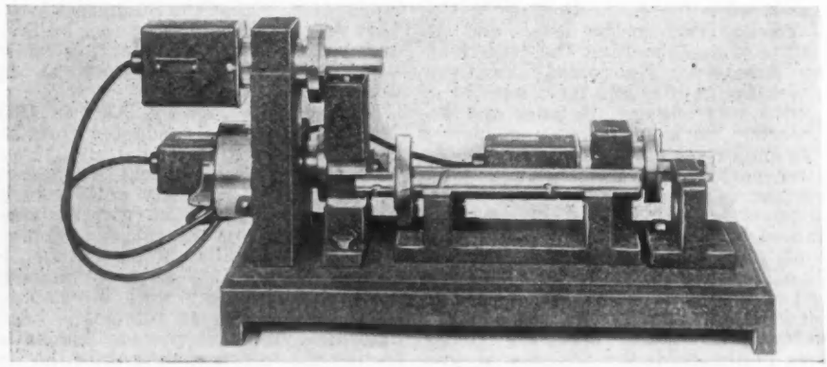


FIG. 3—TRIPLE UNIT COMPRISING ELECTRIC GAGES FOR MEASURING TWO DIAMETERS AND THROW OF CRANKSHAFT

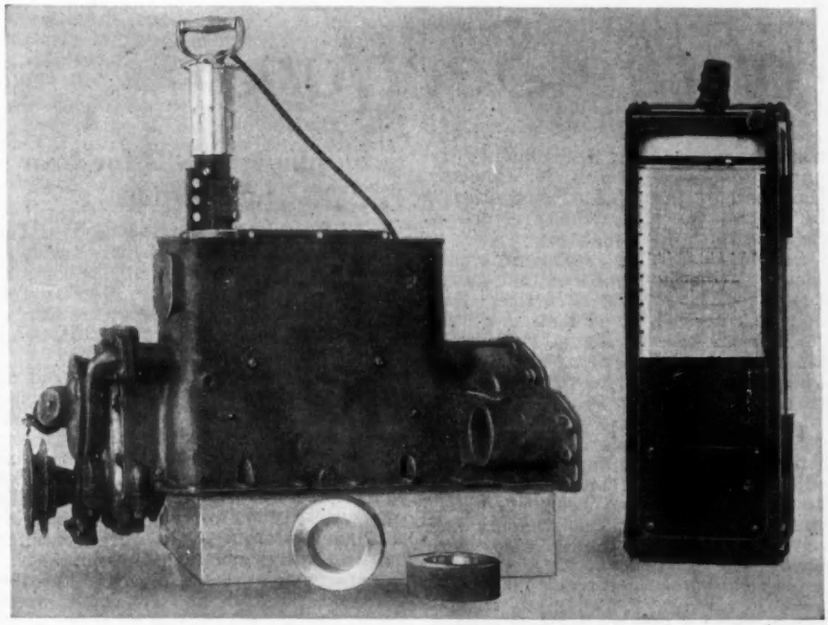


FIG. 4—ELECTRIC GAGE DESIGNED TO MEASURE BORE OF AUTOMOBILE-ENGINE CYLINDER

FIG. 5—PHOTO-ELECTRIC RECORDING DEVICE

the electric gage. A continuous record of the thickness of sheet metal, rubber or paper or the diameter of wire can be made. The distortion of cylinders or ball-bearings when placed under strain can be measured. It is of vital importance in certain manufacturing processes to have actual records of extremely small dimensions or changes in dimensions. This recorder, which makes use of the now well-known photo-electric cell or "electric eye," is the latest tool in the field of accurate measurement.

# Psychology in Production

## *Horning Tells of Mental Cures Applied to Workmen and to Customers—Zero Labor Turnover Not Desirable*

WHEN Harry L. Horning gave his paper at the Semi-Annual Meeting on Why Technical Men Leave Home, he added certain interesting comments on industrial relations that were not a part of the paper. He told of certain mental twists in workmen and in customers and illustrated methods that were used to remedy the conditions. He gave an illustration and Chairman E. K. Wennerlund gave reasons why a small amount of labor turnover is desirable.

Labor turnover was high during the War, Mr. Horning said, when everyone was excited and secret-service operators were watching everywhere. The state of mind of the men was such that accidents were very common. The types of accident could be traced to the state of mind and to the types of the men. Certain men who were employed were a great risk because of their mental ideas and mental index.

During that time it was discovered that some men had a mental twist which amounted to the thought: "I am in a hazardous occupation, and it would not be natural for me to go a month without having an accident." With that attitude, they would immediately proceed to have their accident. Some of them would decide that the occupation was more hazardous than they had thought, so they would decide to have two accidents per month. Deciding that it was much more hazardous still, they would move on to four.

When the number reached four accidents per month, the management would decide that the man was a patient for psychological treatment. He would be told that because he was running a drill press was no reason why he should have accidents, that he had a diseased mind and that there was no necessity for accidents; if he would get over his belief that he had to have an accident, he would not have one. Then he would be sent back into the plant and watched. He would be caught in the act of taking on another accident. Then he would be shown just how and why the accident occurred, and he would then go back to work and make a record of zero accidents per month.

Management and technical men have their greatest opportunity, Mr. Horning said, in acquiring an understanding of the mind and psychology, which gives a better understanding of men and their reactions. It will help in solving many problems. He related the following incident:

One of our customers suddenly discovered that our engines vibrated. Any engineer knows that they do vibrate, but the discovery on the part of this customer was a dis-ease; he was not at ease. He decided that we were very crude; we decided that he had a mental disease and that the way to cure him was to take him through the processes of balancing.

We issued an order that nothing should be done by the salesmen or anyone else only that a special invitation should be given to the president, chief inspector, chief production man and chief engineer of this company to come as my guests to the plant. They were told that nothing could be done to cure the trouble until they came. When they arrived, we showed them each process, including the balancing of the crankshaft, flywheel and connecting-rods, so that a new mental impression should replace their old psychology.

Finally, we assembled an engine from the parts which they had seen tested, placed it on a testing stand and asked the president to feel of it and see how much vibration he could detect. After seeing the care we had taken, he could discern only normal vibration. We asked the men to feel of the engine on the next stand. They did so and said that it was even better than the first. The case was ended when we told them that the second engine was the same one that had been returned from their factory because it vibrated.

That was a complete mental cure. Any other argument or statement, even an analysis of all the forces to be considered in balancing an engine, certified by a group of consulting engineers representing the Society, would never have cured that case. The best type of treatment was to lead them to form new conceptions which would replace the old opinions.

### Workers Should Not Be Static

Mr. Wennerlund confirmed a statement in Mr. Horning's paper to the effect that zero turnover is not desirable, either for the corporation or for the individual, particularly in the technical departments. It is better for a young man to get experience with various organizations after he comes from the technical school; he will be much better off in later life. At least in the younger days of the industry, young men laid a valuable foundation for later growth in this way. This might be looked upon as a necessary part of the young man's education. After that experience is acquired, he does well to find a good solid company and settle down with it.

Undesirable results from zero turnover were illustrated by Mr. Horning. He said that it was noted with pride that no man had left one of the important production lines in the Waukesha plant during more than two years. But it was found that 14 per cent of all the work done on this line had to be done over, and the production cost was $2.20 per part. After the evil results of too stable employment were observed, the cost on that line was reduced to $1.46 and the spoilage was reduced by approximately 75 per cent.

# News of the Sections

## Milwaukeeans Hear About the U.S.S. Akron

AT ONE of the largest Section meetings ever held by the Milwaukee Section, 218 members and guests saw motion pictures of the U.S.S. Akron in process of construction and heard an informal talk by W. C. Young, manager of the aeronautics department of the Goodyear Tire & Rubber Co., on this "dreadnought of the sky." They also saw the motion-picture film entitled, Happy Landings, which was shown by courtesy of the Irving Airchute Co. This picture showed the design, manufacture and use of parachutes, the "lifeboats for the aeronautist."

The meeting was held the evening of Nov. 4 at the Milwaukee Athletic Club, and was preceded by a members' dinner attended by 128, at which entertainment was furnished. At a brief business session, P. C. Ritchie was named Vice-President to complete the unexpired term of Chester S. Ricker.

Mr. Young, in his talk, gave the dimensions of the Akron and its cruising radius and said that it was completed in three years and two weeks after the letting of the contract by the Navy. Powered by eight Maybach 12-cylinder reversible engines of 560 hp. each, the Akron has a cruising speed of 50 knots, a top speed of 67 knots, a cruising radius of 10,500 miles and a practical ceiling of 10,000 ft. Many experts concede the military advantages of the new airship, according to Mr. Young, the cost, speed, personnel, operating expense and maintenance all being in its favor.

Commercial practicability of the airship for transoceanic travel now seems to be only a matter of time, said the speaker, greater speed and comfort for the passengers being major advantages. He described various novel features of the design of the Akron, which were given in detail in a paper presented by Dr. Karl Arnstein and published in the S.A.E. JOURNAL in May, 1929, p. 465. Further advance in this field, said Mr. Young, is dependent upon developments in streamline design, lighter but stronger metals, engine efficiency and mooring-mast control, in all of which great progress has been made in the last decade.

## Fundamentals Expounded at Student Meeting

THE FIRST junior student meeting of the new Section year was held by the Detroit Section on the evening of Oct. 20 in the auditorium of the General Motors Corp. Research Laboratories and was attended by about 250 students from the University of Michigan, the University of Detroit, the Michigan State University, Detroit City College, Cass School of Technology, the Detroit Institute of Technology and the General Motors Institute of Technology.

Chairman Alex Taub opened the meeting with a few introductory remarks and introduced R. N. Janeway, Chairman of the Student Activities in the Detroit Section, who presided at the meeting.

Arnold Lenz, plant manager of the Chevrolet foundry, spoke on The Development of Foundry Practice. Sam Morgan, director of education at the Buick Motor Co., spoke on Fundamentals in Forging Practice. Mr. Marlin, superintendent of gages for the Chrysler Corp., spoke on Progress in Precision Manufacture.

Each speaker discussed the fundamentals of his particular branch of the industry from its earliest date. After the three papers had been presented, many questions that the students had written out during the meeting were answered.

## Passenger Cars for Fleets and Public Discussed

THREE PAPERS on passenger automobiles were presented at the meeting of the Metropolitan Section at the A. W. A. Clubhouse in New York City on Oct. 22. Sixty-eight members and guests were present at the dinner, which was enlivened by popular music rendered by an orchestra, and 150 attended the technical session.

R. A. Wotowich, of H. L. Doherty & Co., dealt with the subject, The Salesman's Car; Is It Cheaper to Rent or Buy?

F. K. Glynn, of the American Telephone & Telegraph Co., gave a paper on The Passenger Car for the Fleet versus the Passenger Car for John Public. The information given in it was based on replies from a number of passenger-car-fleet operators to a questionnaire sent out by the Section.

Why Won't the Car Manufacturer Give the Public What It Wants was the subject of an illustrated talk by J. A. C. Warner, General Manager of the Society. Mr. Warner pointed out that all of the millions of cars bought and in operation cannot be wrong from the standpoint of public demand and acceptance but manufacturers will have to adopt sound scientific methods to determine what will be most acceptable to future buyers. It should be compulsory, he said, for the engineering and production executives to spend enough of their time in direct contact with field conditions to obtain a true concept of conditions and requirements. Much useful evidence of human reactions to appearance and style can be gathered from related lines such as millinery, furniture, paints and clothing. Pioneering in engineering, he remarked, pays only those who know what, how and when to pioneer, but to the intelligently courageous go the big rewards. Although cars are not always bought on their merits, this does not lessen the engineer's responsibility to do his best in the way of engineering for the consumer.

## Sulphurized Oils for Gear Lubrication

LUBRICATION from the days of the ancient chariot was briefly reviewed by William H. Oldacre at the Oct. 27 meeting of the St. Louis Section following a members' dinner at the Coronado Hotel. The meeting was attended by 45 members and their guests.

Although fatty-oil mixtures used as lubricants have been found by archeologists on the axles of ancient chariots, said Mr. Oldacre, lubrication is one of the least-known subjects of the industrial world today. In the last two or three years higher and higher unit pressures in motor-vehicle transmissions and differentials have created much more exacting demands on lubricants.

Research work conducted by the Gleason Works, the General Motors Corp. Research Laboratories, the Timken Roller Bearing Co. and others has demonstrated the increased load-carrying capacity of lubricants containing sulphur and lead soaps. Some types of gear require such lubricants for satisfactory operation; unfortunately, however, many such lubricants have a characteristic that results in increased bearing wear which seems to be associated with high percentages of lead soap together with high percentages of certain forms of sulphur. Therefore it was necessary to produce carefully balanced and homogeneous lubricants to minimize the danger of excessive wear.

Sulphurized oils are now available that contain as low as 0.5 per cent of combined sulphur and that will carry bearing loads of 20,000 lb. per sq. in. at a rubbing speed of 420 ft. per min. Demonstrations in the Timken lubricant-testing machine show that a straight petroleum lubricant that fails at a load of 10,000 lb. per sq. in. will, with the addition of 10 per cent of sulphurized fatty oil, carry 20,000 lb. per sq. in. or more.

Research work on the new type of lubricant is only beginning, said Mr. Oldacre, and it is felt that the oil men and the automotive engineers should cooperate in the work to the fullest extent. The speaker commended the work of the S.A.E. Lubricants Committee and urged the cooperation of all Sections with the Committee and the parent Society.

## Making a Survey for a Transport Operation

HOW TO MAKE a suitable survey of a proposed motor-truck transportation operation to enable the making of a correct selection of the equipment to be used was explained by Fred B. Lautzenhiser, transportation engineer of the International Harvester Co., at the Nov. 12 meeting of the Baltimore Section. The meeting was held at the Emerson Hotel, where 110 partook of the members' dinner and

several more came later to hear the address. Music was provided during the dinner and the session was opened with a short business meeting.

Mr. Lautzenhiser's presentation was in the form of an explanatory talk about a questionnaire form intended to be filled in with the data as to the proposed operation and its requirements, recommendations as to equipment and cost estimates. Forms to be filled in by the manufacturer's engineer with data on the pulling and climbing ability of the recommended power units and load distribution on the chassis were also shown. These were supplemented by sheets of data on State restrictions on vehicle sizes and weights in Maryland, Delaware, New Jersey, Pennsylvania and New York State.

Following the talk, a four-reel motion picture entitled The International Trail was exhibited. This showed the complete sequence of manufacturing processes in the truck plant of the International Harvester Co.

Those who took principal parts in the discussion were Adrian Hughes, Jr., of the United Railways & Electric Co. of Baltimore; J. Arley Robinson, of the Hendler Creamery Co.; John A. White, of the Mack-International Motor Truck Corp.; and Edwin S. Ziegler, of the York-Hoover Body Co.

## Pittsburgh Discusses Motor Operation

SEVENTY dinner guests attended the Nov. 5 meeting of the Pittsburgh Section at the Fort Pitt Hotel and many others came in later to listen to a paper on Important Factors Affecting Modern Motor Operation, written by Ralph R. Teetor, vice-president in charge of engineering of the Perfect Circle Co., and read by H. M. Bramberry, of the same company. This aroused such interest that Mr. Teetor was plied with questions for two hours.

C. R. Noll, Vice-Chairman of the Section, was toastmaster and also presided at a short business meeting.

After the dinner, talking motion pictures were shown depicting the manufacture of piston-rings, from the individual castings through the 14 machining operations necessary to form the finished rings.

The importance of accuracy in cylinder finish cannot be over-stressed, said Mr. Teetor. This includes not only accuracy in machining but of design. The cylinders of many engines, though accurate when cold, are greatly distorted when heated to operating temperatures. At high engine-speeds, the piston-rings are drawn so rapidly over the comparatively rough surfaces of the cylinder bores that they tend to vibrate and blow-by may become excessive.

The two greatest evils arising from incorrect piston-rings, known as "blow-by" and "oil-pumping," were discussed by the author.

Among many who discussed the paper were: A. R. Platt, a member of the S.A.E. Wheel-Alignment Committee; Charles F. Kells, of the West Penn Power Co.; S. P. Marley, Jr., of the Mellon Institute of Industrial Research; R. Lancaster, of the Equitable Auto Co.; A. D. Tiel; P. H. Rudd; Charles R. Noll, of the Gulf Refining Co.; B. H. Eaton, of the Bell Telephone Co.; and Murray Fahnestock.

## Vibration - Absorbing Engine Suspension Explained

THREE SCORE members and guests of the Canadian Section attended a members' dinner and a technical session at the Royal York Hotel in Toronto on the evening of Oct. 21, at which Newton F. Hadley, chief engineer for Plymouth and De Soto cars, explained the novel suspension of the powerplant in Plymouth cars. The address was illustrated with a three-reel sound motion-picture film showing the vibration-absorbing characteristics of the suspension.

At a brief business session Chairman George W. Garner announced that the Governing Board had unanimously decided to purchase a loving cup for presentation to H. R. Combs, the first Chairman of the Section, who was mainly instrumental in effecting its organization. Announcement was also made of the election of Alexander M. Bentley, general manager of the Exide Battery Co. of Canada, as Vice-Chairman of the Section. Mr. Combs was elected by acclamation to represent the Section on the Nominating Committee of the Society, with Marcus L. Brown and F. M. Horton as alternates.

## Highways and Their Use

PHILADELPHIA Section's monthly meeting on Nov. 12 was devoted to the subject, Highway Construction from the Viewpoint of Licensing and Law-Enforcement Authorities. Harold G. Hoffman, commissioner of motor vehicles of the State of New Jersey, was the speaker, and at the conclusion of the address B. B. Bachman, of the Autocar Co., led the discussion.

Members of the Philadelphia Chapter of the Pennsylvania Motor Truck Association had been invited to attend the meeting, which was held as usual in the rooms of the Philadelphia Automobile Trades Association. A members' dinner preceded the technical session and was followed by entertainment features arranged for by O. M. Thornton.

## New St. Louis Section Officers

AT THE OCTOBER meeting of the St. Louis Section new officers to serve during the 1931-1932 administrative year were elected as follows:

Chairman—George C. Stevens, manager, St. Louis branch, Diamond T Motor Car Co.

Vice-Chairman—George P. Dorris, automotive engineer, of St. Louis.

Treasurer—Robert M. Pease, manager, St. Louis factory, Axelson Aircraft Engine Co., reelected.

Secretary—William G. Jenkin, president, Jenkin-Guerin Oil Co., reelected.

## Engineers' Psychology Analyzed

THE MENTAL GEARS of Engineers was the title of an address given at the Nov. 10 meeting of the Buffalo Section by Dr. Yale S. Nathanson, of the department of psychology of the University of Pennsylvania.

Forty-six members and guests were present at the meeting, which was held at the Hotel Statler, and a brief business session was held for election of representatives of the Section on the Nominating Committee and the Sections Committee of the Society. A. J. Underwood, director of Sections activities, gave a short talk relating to the Society's work and that of the Sections.

Among those who took part in the discussion on the psychology of engineers were John H. Taylor, Marsden Ware, William H. Schaefer, R. G. Hatch and B. F. Jones.

## Detroit Body Activity Discusses Various Subjects

THREE PAPERS dealing with as many phases of body construction were given at the Detroit Section meeting on Nov. 9, which was dedicated to the Body Activity. The meeting, which was attended by 275 members and guests, followed a dinner held at the Book-Cadillac Hotel.

William L. Hoge, vice-president of the Mengel Body Co., of Louisville, dwelt upon the many advantages of wood used in automobile body work, important among which are resilience, shock-and-sound-absorbing capacity, poor heat-conductivity and ease of accurate machining. The possibility of fingerjointing and of using glued veneers, and the treatment of wood with a view to preventing its decay, were mentioned. The speaker concluded by pointing to the considerable research and development work going on in the fields of wood manufacture and woodworking, and expressed his conviction that wood will long continue to be utilized in the manufacture of automobile bodies.

Automotive-body steel sheets were considered by R. O. Griffis, associate director of research of the American Rolling Mill Co. Such sheets, he said, are made by the hand-operated hot-mill, continuous hot-mill or continuous cold-mill process, and the typical routings for producing high-finish sheets by these methods were explained. Next he described the grain structures, illustrating them by means of photographic slides, and outlined testing operations and specifications used in sheet-steel manufacture.

The third paper, presented by Howard Ketcham, director of the Duco color-advisory service of E. I. duPont de Nemours & Co., dealt with Some European Sources of Automotive Color Inspiration. He stated that the stylists employed by leading couturiers of Paris are most ardent colorists who advocate color as the easiest, least costly and most desirable escape from standardized appearance. The speaker described many effective color combina-

tions observed in clothing materials, gobelins and automobile bodies, remarking in conclusion that "there are some elements of usefulness for the automotive industry in the methods followed by the successful couturiers in predetermining style colors. . . . The care, thought and skill represented in each color harmony in the color masterpieces of Europe lend emphasis to the fact that the successful use of color in design is far more than a matter of luck resulting from haphazard procedure."

## Highway Safety Was Oregon Section's Topic

BRAKES, highway alignment and illumination and reaction time were covered in three papers presented at the Nov. 6 meeting of the Oregon Section, which was held at the Multnomah Hotel, in Portland, with 76 Section members and guests attending. The speakers were F. G. Stanley, chief engineer of the Raybestos-Manhattan Co., of Bridgeport, Conn.; Burdette Glenn, assistant professor of civil engineering at Oregon State Agricultural College, Corvallis; and J. G. Brumbaugh, professor of psychology at the same institution.

Brakes, said Mr. Stanley, have changed gradually since 1926, when all service brakes were of the external-contracting type, to 1931, when the only automotive vehicles equipped with this brake are a few trucks built from assembled parts, all others being equipped with the internal-expanding type. While all brake problems have not been solved, he feels that great progress has been made and the cure of the troubles remaining is largely in the hands of the drivers and operators.

### Highway-Design Factors

In designing the modern highway, said Professor Glenn in his address, the engineer must consider the three fundamental factors of capacity, safety and economy, as designing a road for any one of these without affecting the other two is impossible. While the highway engineer has no direct control over the speeds at which cars travel, he can increase the average spacing between them by providing a roadway having a smooth surface of adequate width, wide shoulders, horizontal curves that are properly super-elevated and widened, long vertical curves, adequate sight distances on all curves, suitable treatment of intersections and guard rails wherever necessary.

Curves on first-class highways should be super-elevated for speeds of 50 to 60 m.p.h., which differs materially from present design. To provide for a gradual transition from a tangent to a curve with maximum riding-quality, a spiral curve of gradually increasing curvature should connect the tangent with the curve, the super-elevation to be increased with the degree of curvature. Adequate sight distances should be provided on all curves, and where reverse and compound curves are required they should be separated by 200-ft. tangents. While a sight distance of 500 ft. would be adequate if cars were driven in their proper lanes, the American Association of Highway Officials recommends a sight distance of 800 ft. for first-class highways.

Night driving has increased only 30 per cent in the last 10 years, yet accidents have increased 50 per cent because of the limited range of vision at night. The range of the headlight driving beam is not sufficient for present speeds and the glare from approaching vehicles tends to reduce this range materially.

### Driver-Reaction Time Classified

Driver reaction time is of four kinds, asserted Professor Brumbaugh, which, in the order of the complexity of the outside conditions involved, are: reflex or primary, simple automatic sense, discrimination and judgment-association reaction times. The second form is the one constantly employed in automobile driving. The last two are complex and dangerous because they occur most frequently when conditions are complicated by the uncertain combination of two or more drivers with cross purposes and opposing machines. In the first of these, the driver must discriminate quickly between different courses of action and choose the one that leads to safety. While the last form of reaction time is not fundamentally different from the third in its danger implications, it adds more difficulty in that a quick choice between two or more alternatives involving a mental comparison and an act of judgment must be made.

## Wickenden Tells Chicagoans about Steels

THE PROPERTIES and Selection of Automotive Steels was the title of a paper presented by Thomas H. Wickenden, of the International Nickel Co., at the joint meeting of the Chicago Section of the S.A.E. and the Chicago Chapter of the American Society for Steel Treating at the Hotel Sherman on Nov. 3. The meeting was attended by 165 members of the two societies and their guests. Dinner was served in the Bal Tabarin to 129 and "entertainment de luxe" was provided.

Another feature of the program was a talk by J. Parker Van Zandt on A Century of Progress, in which the speaker told about preparations for the international exposition to be held in Chicago in 1933 and the parts that metallurgy and engineering will have in this great event.

### Information for the Designer

In his comprehensive technical paper, illustrated with graphs, Mr. Wickenden dealt with reduction of weight in motor-vehicle structures, through the use of metals of high resistance to stress, impact and wear and through correct design, heat-treatment and finish. He discussed the S.A.E. data sheets on the physical properties of steel, the difficulty of preparing a representative physical-property chart because of the variations in chemical analysis, in properties of steel of the same chemical analysis but different heats, and in heat-treating due to the personal equation. The method decided upon by the S.A.E. Subcommittee on Physical-Property Charts for the presentation of these charts in the form of frequency or probability curves was described briefly and illustrated by the graphical method.

When designing an airplane, automobile, truck or tractor, said Mr. Wickenden, the engineer should work with the metallurgist in the early stages. The latter part of the paper dealt with the most suitable materials for various parts, their hardening and their various properties.

## Highways, Safety and Truck-Operators' Problems

A PROGRAM of three good papers was presented at a gathering of 33 members and guests of the Kansas City Section on Nov. 13 at the LaSalle Hotel. A members' dinner and a short business session preceded the technical meeting. The relation of highway construction to vehicle operation and safety and the relation of motor-truck to rail transportation were the subjects of the papers presented and discussed.

T. H. Cutler, chief engineer of the Missouri State Highway Department, gave a paper on Highway Construction and Law, in which he discussed the proposed law, that failed of enactment by the last legislature, prescribing vehicle weights and lengths. The highway-transportation committee of the American Association of State Highway Officials, of which Mr. Cutler is a member, expects to have ready for the State Legislatures of 1932 a rather complete report of studies made, he said, for possible use in suggested uniform vehicle laws in all the States. A meeting of this committee was scheduled for Dec. 2 in New York City.

The second paper, by C. E. Lang, president of the Missouri Motors Distributing Corp., was entitled Truck Operators' Problems and dealt with motor-freight and passenger competition with railroad transportation as mentioned in the report of the Hoover Committee on Recent Economic Changes. The speaker dealt in this connection with the taxation and regulation of trucks as viewed by the motor-truck operators. In conclusion he said he feels that the engineers of the Society "should leave no stone unturned in its efforts to provide equipment that will enable the operators to continue to justify their existence as a part of the leading transportation principle of which the world has knowledge."

Under the title, Construction and Safety Factor in the Public Highway, E. R. Rogers, district manager of the Portland Cement Association, discussed road-surfacing material as it affects and is affected by motor-vehicle traffic; also the design of highways as related to safety.

Among those who took leading parts in discussion of the papers were C. E. Brosseau, of the Mack Truck Co.; G. R. Gwynne, Kansas City sales manager for the White Truck Co.; Bernard Wahle, regional manager for the Pickwick-Greyhound Lines; and A. E. Gresham, chief engineer of the Standard Steel Works.

## Long Session at Los Angeles on Brakes and Safety

APPROXIMATELY 175 members and guests attended the dinner and meeting on Brakes held at the Elks Club, Los Angeles, by the Southern California Section on Nov. 6. Following a business meeting for election of representatives to the Nominating and Sections Committees of the Society, Deputy Chief Davis, of the Los Angeles Police Department, spoke briefly on Training Drivers, emphasizing particularly the need of employing men who are mentally and physically as nearly perfect as possible and giving them intensive training similar to general railway practice. Efficient police protection could reduce accidents approximately 80 per cent, he said, but the public driver must be disciplined the same as the driver for the fleet operator.

R. H. Croninger, consulting engineer of San Francisco, read a paper illustrated with slides on The Progress of Automotive Brake-System Forces.

The third speaker, Ray Cato, chief of the California Highway Patrol, described the organization and purpose of his department, laying particular stress on the education of his 375 men before their assignment to patrol duty. He said that one person is killed every 4 hr. in California and one every 17 min. in the United States, and that records show that accidents are more frequent on good high-speed roads than on poor roads.

P. K. Ducker, of the Southern California Edison Co., stated that truck operators do not keep their brakes in satisfactory condition. He cited brake tests made on the highways which revealed that trucks were being overloaded beyond their braking capacity and suggested that the truck operator set his house in order immediately to avoid adverse legislation.

Owing to the illness of A. J. Ford, of the State Motor Patrol, his paper on Law Enforcement was read by Mr. Sharkey, who is in charge of headlight enforcement for the patrol.

Because of the short time remaining, E. Favary asked permission to read his paper on Brake Fundamentals at a special meeting on Nov. 9 at the Frank Wiggins Trade School.

A lively discussion of the various papers lasted until 11.30 p. m. and several interpretations of the State law were made by representatives of the law-enforcement bodies.

## Addresses on Diverse Subjects Given at Cleveland Meeting

REVOLUTIONARY changes that have developed in the paint and varnish industry in the last eight to ten years were reviewed by Robert J. Moore, of the Bakelite Corp., in a paper presented before 100 members and guests of the Cleveland Section at the Hotel Statler on Nov. 9. The gathering also heard D. C. Elliott, of the Midland Bank of Cleveland, analyze the automobile replacement market. Before the technical session, 40 members gathered at the customary monthly dinner, at which entertainment was provided, and a short business session was held for election of representatives on the Nominating and Sections Committees of the Society.

In his paper on New Protective Metal Coatings, Mr. Moore told briefly about the materials and methods used in making a modern varnish or enamel and about the composition and properties of the most widely used synthetic resins. The major portion of his paper was devoted to the development of the new 100-per-cent oil-reactive resins, the durability and chemical resistance of the film they produce, and the application of these materials to form protective coatings for metal, with particular reference to the automobile and aircraft industries.

In discussion, Orel A. Parker raised a question of cost as compared with that of natural resins. C. Klug expressed interest in the acid-resisting qualities of the new resins and was told that short-oil finishes are the more resistant. A query by W. H. Whitacre brought out the statement that all methods can be used in applying the coatings. A. E. Weaver suggested that prolonged exposure probably would soften the gum, and another member mentioned that the differences between the paints and the insulation materials is on the phenol, and not the formalin, side of the reaction.

An average car life of 7½ years was used by Mr. Elliott as the basis for estimating the 1932 market for automobiles, instead of 7 years as heretofore. This would give a replacement demand very little different from that of the last few years, he said. Adding an estimated demand from new drivers for 200,000 cars and an export demand not to exceed 25,000, he derived a total of 3,320,000 as a reasonable estimate of the number of new automobiles to be expected to be demanded of the industry next year, assuming a reasonable general business revival.

## Future Cars Discussed at Dayton

IMPROVEMENTS that are likely to be incorporated in the automobiles of a few years hence were pointed out by T. J. Litle, Jr., engineer and industrialist of Detroit and Dayton, at the Oct. 29 meeting of the Dayton Section. Following the members' dinner, 50 members and their guests listened attentively to Mr. Litle's paper and many took part in the discussion. The discussers debated the possibilities of light alloys, two-cycle engines, air-cooling and liquid-cooling with Prestone, rear engine-mounting and the use of rubber for vibration and sound insulation.

Mr. Litle made a plea for originality in design instead of continuing to be slaves of tradition and style. He referred with gratification to the notable exception of a clever young man from Chicago who stepped to the front of the industry by creating new design trends. If we would place the engine in the rear of the car, Mr. Litle believes that we would simplify and reduce the cost of the car and secure greater riding comfort and customer appeal. The car of the future, he said, unquestionably will be streamlined to reduce wind resistance and the excessive weight of the vehicle, which has been referred to facetiously as "an upholstered truck."

The ingenious and resourceful American engineers can be expected to make clever adaptations of some of the newer alloys so as to reduce car weight, avoiding use of high-priced aluminum. Developments in aircraft are certain to affect motor-car engineering and design, asserted Mr. Litle, who referred to the light fuselage and seat construction and expressed belief that future motor-cars may be blown along the road by means of propellers.

Every argument in favor of air-cooled engines in aircraft applies also to the automobile, and Mr. Litle believes the time will come when all automobiles will be air-cooled. Very large cars of the future will need engines of at least 300 hp. and these will have some device such as the supercharger for augmenting the power output. Sustained speeds of more than 100 m.p.h. will be possible, and private and public rights-of-way to accommodate such cars are in the offing.

Announcement of an entirely new type of transmission in the near future was also predicted by the speaker, who has seen demonstrated the transmission of power and light without wires. He foresaw electric transmission lines radiating along the highways and furnishing power to receiving sets in vehicles driven by electric motors.

## Syracuse Has a Fuels Session

FUELS for internal-combustion engines were the subject of discussion at the November meeting of the Syracuse Section, which was held at Drumlins the evening of the 5th and attended by 50 members and guests, of whom 41 were present at the members' dinner, at which entertainment was provided.

T. A. Boyd, of the General Motors Corp. Research Laboratories, pointed out in his paper that automobile engineers, in leaving to the producers of fuels the burden of fitting fuels to engines, have overlooked the fact that they can do something toward fitting the engine to the fuel. However, heretofore not enough information on the essential properties of fuels has been available to the engineers to enable them to do much in this direction. Now we have important and valuable information on the antiknock properties of the gasoline sold and on the vapor-locking tendency in current motor-cars.

Causes of vapor lock were said to be the presence in gasoline of light, low-boiling hydrocarbons and the absorption of engine heat by the fuel-feed system. The corresponding cures are to leave out of gasoline the low-boiling constituents or to keep the fuel-feed system cooler. The latter is regarded as preferable, because it gives easier engine starting and the low-boiling hydrocarbons give gasoline a higher antiknock value. The speaker gave figures of temperatures at which gasolines now being marketed begin to give vapor-lock trouble and the temperatures to which the fuel is heated in present cars under normal driving conditions. He

(*Concluded on p.* 489)

# Personal Notes of the Members

### *C. O. Guernsey Now Chief Engineer*

From his former position as chief engineer of the automotive car division of the J. G. Brill Co., of Philadelphia, Charles O. Guernsey has been advanced to that of chief engineer of the company. He had held the former position since 1923, before which he had been connected for eight or more years with the Service Motor Truck Co., of Wabash, Ind. During the World War Mr. Guernsey served his Country as captain and chief draftsman in the engineering section of the motors division of the Quartermaster's Department in the City of Washington.

Admitted to Member grade in the Society in 1914, Mr. Guernsey has rendered the organization very active service, as a member of the Truck Committee, the Sections Committee and the Meetings Committee and as Second Vice-President representing stationary internal-combustion engineering. He has been for years a member of the Pennsylvania Section, of which he was Secretary in 1924 and Chairman in 1925.

### *LePage Elected Vice-President*

W. Laurence LePage, formerly chief engineer of the Kellett Aircraft Corp., of Philadelphia, has been appointed vice-president of the corporation, in charge of engineering. Mr. LePage is well known to members of the Society, especially for his work in aeronautics, particularly with reference to the Autogiro. He has been a Member since 1924, was a member of the Aeronautic Committee in 1929 and a member of the Publication Committee last year. He was Vice-Chairman of the Philadelphia Section last year and is now Chairman of the Section. He has presented the following papers at meetings of the Society: The Light Airplane and Low-Powered Flying, The Autogiro Analyzed, and Design Problems of the Autogiro.

### *E. W. Templin Joins the Curtis Mfg. Co.*

Recent appointment of E. W. Templin as chief engineer of the Curtis Mfg. Co., of Los Angeles, brings to that company the long experience of a qualified engineer in the motor-truck field. Since becoming a Member of the Society in 1918, Mr. Templin has been connected in an engineering capacity with the Selden Motor Truck Co., of Rochester; the truck development department of the Goodyear Tire & Rubber Co., of Akron, Ohio; the Six Wheel Co., of Philadelphia, as chief engineer; the Graham Brothers division of the Chrysler Corp., of Detroit, as supervisor of design and construction of special equipment; and the Mavis Bottling Co., of New York City, as manager of motor equipment.

Mr. Templin has been very active in the work of the Society. He served on the Motorcoach Division of the Standards Committee from 1924 to 1928, was a Councilor-at-Large and a member of the Transportation Committee in 1929, and the following year served on the Transportation and Maintenance Committee. He was Treasurer of the Pennsylvania Section in 1925 and its Chairman the following year and was a member of the Cleveland Section. He is the author of four papers presented before meetings of the Society, as follows:

What Motor-Trucks Need to Supplement Pneumatic-Tire Equipment, Highway Transportation as It Affects the Automotive Engineer, The Motorcoach Builder, Attitude Toward Changes in Standard Design, and Six-Wheel Motor-Vehicle Development History.

### *Janeway Permanently with Chrysler Corp.*

Robert N. Janeway, who for a year past has been connected with the Chrysler Corp., of Detroit, in a consulting capacity requiring only part of his time, is now permanently connected with the corporation as consulting engineer in the research division in association with R. K. Lee, director of research. The Chrysler Corp. now controls the patent situation on the combustion-chamber development that Mr. Janeway has carried on in recent years but the results of his work are still available to the industry through licensing arrangements.

### *Donkin Goes with Eaton Spring Co.*

The post of assistant general manager of the coil-spring division of the Eaton Spring Co., of Detroit, is now held by W. T. Donkin, formerly chief engineer of the Cleveland Wire Spring Co., who is well known to Society members for his research work on valve springs. Since being elected to Member grade in 1925, Mr. Donkin has presented three papers on valve springs, the first and third having been prepared in collaboration with H. H. Clark, of the Cleveland Wire Spring Co. These papers were entitled, Notes on Valve-Spring Surge, Valve-Spring Design, and The Electric Telemeter and Valve-Spring Surge.

H. H. Clark, who was a member of the sales and engineering staff of the Cleveland Wire Spring Co., stationed in Detroit, is now chief engineer of the coil-spring division of the Eaton Spring Co.

### *Kreusser a Museum Director*

The best wishes of a host of his Detroit friends follow O. T. Kreusser, affectionately known as "Pop," in his notable change of occupation to the directorship of the Museum of Science and Industry in Chicago. Mr. Kreusser, who has been a Member of the Society since 1919, is widely known for his work as director of the General Motors Proving Ground at Milford, Mich., and during the past year as in charge of engineering tests for the Fisher Body Corp. division of General Motors. He has been an active member of the Detroit Section and has given several informative and amusing papers at Detroit meetings. These were entitled, Providing the Engineer with Service Data, Automotive Proving Grounds of the General Motors Corp., and Automobile Bodies from the Abstract Customer's Viewpoint.

### *Beisel Joins Chance Vought Corp.*

Rex B. Beisel recently resigned as vice-president and chief engineer of the Spartan Aircraft Co., of Tulsa, Okla., and is now assistant chief engineer of the Chance Vought Corp., of East Hartford, Conn. He was elected a Member of the Society in 1929 and last year gave a paper before the Wichita Section on the Possibilities of Liquid-Cooled Aircraft Engines, which was published in the S.A.E. JOURNAL for October, 1930, p. 403.

**Dorsey Lawrence Botham** has accepted the position of an engineer with the Wisconsin Foundry & Machine Co., of Madison, Wis.

**R. Y. Copland** has become factory manager of the Dominion Rubber Co., Ltd., of Kitchener, Ont., Canada. He formerly was director of the planning and engineering department of the same firm at Montreal.

**Arthur B. Cumner**, formerly president of the Cumner Auto Services, Inc., of White Plains, N. Y., is now vice-president of Jenkins Service & Cumner's, of the same city.

**Ralph J. Duckworth**, formerly a layout draftsman with the Reo Motor Car Co., of Lansing, Mich., has accepted a position with the Buick Motor Co., of Flint, Mich.

**Don M. Duncan** has been appointed assistant mechanical superintendent for the *Cleveland Shopping News*, of Cleveland. His former connection was with the Duplex Printing Press Co., of Battle Creek, Mich., as assistant chief engineer.

**Chris J. Fields**, formerly a layout man in the body department of the Pierce-Arrow Motor Car Co., of Buffalo, now serves the Edward G. Budd Mfg. Co., of Detroit, in a similar capacity.

**Walter M. Hartung**, formerly engineer for the Aircraft Improvement Corp., of New York City, is now dean of aviation at Beckley College, of Harrisburg, Pa.

**Hall H. Hibbard**, who was for several years project engineer with the Stearman Aircraft Co., of Wichita, Kan., has accepted a similar position with the

(*Continued on p.* 38)

# Applicants for Membership

ALLEN, J. R., aircraft designing engineer, Ford Motor Aircraft Division, *Dearborn, Mich.*

BAKER, GEORGE A., draftsman, Forest Service, Department of Agriculture, *City of Washington.*

BEECH, WALTER H., president, Curtiss Wright Airplane Co., *Robertson, Mo.*

BIRKBY, ALFRED, layout, Chrysler Motor Co., *Detroit.*

BIRREN, WILLIAM B., western service representative, Wright Aeronautical Corp., *Paterson, N. J.*

BLACK, JOHN PAUL, director and general manager, Standard Motor Co., Ltd., *Coventry, Warwickshire, England.*

BRUCE, ERNEST G., aeronautical engineer, Fokker Aircraft Corp., *Glendale, W. Va.*

BUSSY, ROGER M., automobile engineer in Persia, Anglo-Persian Oil Co., *London E. C. 2, England.*

CARP, PETER, chief engineer, J.A.R., *Brasou, Roumania.*

CAVIN, GUSTAVE, chief mechanical engineer, Canadian Locomotive Co., Ltd., *Kingston, Ont., Canada.*

CONBOY, RAYMOND G., shop superintendent, Bronx Buick Co., The Bronx, *New York City.*

ELDRIDGE, LEONARD C., chief lubrication engineer, Shell Petroleum Corp., *St. Louis.*

EVERS, LUDGER, body draftsman, Fisher Body Corp., *Detroit.*

FAROUGH, RAYMOND A., purchasing engineer, Ford Motor Co., *Dearborn, Mich.*

FIZZELL, JAMES LESTER, vice-president and treasurer, National Steel Products Co., *Kansas City, Mo.*

GERHARDT, H. W., shop foreman of bus garage, Johnstown Traction Co., *Johnstown, Pa.*

GHOSH, BAIDYA NATH, proprietor, Indian Motor Transport Co., *Benares City, India.*

**The applications for membership received between Oct. 16 and Nov. 15, 1931, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.**

GRAVELINE, JOSEPH HENRY, instrument repairman, New York & Queens Electric Light & Power Co., *Flushing, N. Y.*

HANE, CLARENCE ARTHUR, manager of operations, National School of Service Station Operation, *Los Angeles.*

HOUSTON, FRASER C. A., department manager, automotive sales, Exide Batteries of Canada, Ltd., *Toronto, Ont., Canada.*

KELLER, H. M., superintendent of transportation and claims, Northern Indiana Public Service Co., *Hammond, Ind.*

KRAMER, FRED S., 26 West 96th Street, *New York City.*

LEE, WALTER E., assistant director, research laboratories, Standard Oil Development Co., Bayway, P. O. 485, *Elizabeth, N. J.*

LENDL, CHARLES A., mechanical and aeronautical engineer, 75 Riverside Drive, *New York City.*

LOWTHER, WILFRED W., chief engineer, Donaldson Co., Inc., *St. Paul, Minn.*

LUCAS, JOSEPH E., president, Diesel Oil Sales Co., *Seattle, Wash.*

MILLER, GEORGE HERBERT, sales representative, Collins & Aikman Co., *Farnham, Que., Canada.*

MITREVICH, KONSTANTIN S., mechanical engineer, Cheliabinsk tractor plant, *Cheliabinsk, U. S. S. R.*

PARTENHEIMER, JOSEPH E., manager product development, Fisk Rubber Co., *Chicopee Falls, Mass.*

PATRICK, JOHN SHAW, lecturer in mechanical engineering, Technical College, *Hull, England.*

PETERS, HANS M., 27-07 Grand Ave., *Astoria, L. I., New York City.*

REDICK, ARTHUR WILLIAM, mechanical foreman, South African Railways, *Johannesburg, South Africa.*

SPENCE, GUY H., commercial service representative, Ford Motor Co., *City of Washington.*

STEWART, CECIL HAROLD, automobile mechanic, first class, Shell Oil Co. of California, *Los Angeles.*

SUEZ, KYEUYOONG ALBERT L., sales engineer, General Motors China, Inc., *Shanghai, China.*

SWEET, JOSEPH B., chief engineer, Reliable Automotive Co., and service manager of Mack-International Motor Truck Co. of Fresno, *Fresno, Calif.*

VAN HORN, E. C., sales engineer, Northwest Motor Parts Co., Inc., *Seattle, Wash.*

VILLERS, C. J. J., production manager, Automobiles Mathis, *Strasbourg, France.*

VON DORRER, WOLFGANG, chief designer, Szekely Aircraft Engine Co., *Holland, Mich.*

WALKER, JOHN B., sales manager, Greyhound Management Co., *Cleveland.*

WESSON, CHARLES M., chief of technical staff, Office Chief of Ordnance, War Department, *City of Washington.*

WHITE, JOHN ALOYSIUS, branch manager, Mack-International Motor Truck Corp., *Baltimore.*

ZIMMERMAN, H. W., engineer, Automotive Maintenance Machinery Co., *Chicago.*

# News of the Section

(*Concluded from p.* 487)

told of the work done by the Cooperative Fuel-Research Committee on the vapor-lock problem and also in developing the octane rating as a measure of antiknock quality.

### How Fuel Quality Is Controlled

A. L. Beall, of the Vacuum Oil Co., spoke on Quality Control of Motor Fuels. He reviewed various methods used for testing the volatility, antiknock quality, vapor pressure, gum content, sulphur content and other characteristics. Gasolines are invariably a compromise to secure the optimum volatility for cars used under particular climatic conditions and to provide adequate antiknock value and useful economy, he said. No gasoline meets the ideal in every particular, and only skillful treatment of a series of compromises enables the producer to supply what the car driver calls a "good gasoline." In controlling the quality, the needs of car models of a number of years must be satisfied and those of cars of the future must be forecast. Improvement of the quality year by year, he said, has been greater than the improvement in the fuel systems of the cars and possibly than of the combustion-chambers of the engines.

Among those who took most active part in the discussion on the papers were C. P. Grimes, of the Grimes Brake Engineering Service; Hubert Walker, of the American LaFrance & Foamite Industries; and Carl Doman, of the H. H. Franklin Mfg. Co.

## Light Alloys for Motor-Vehicles

FRANK JARDINE, chief engineer of the castings division of the Aluminum Co. of America, described some possible uses of light alloys in motor-vehicle construction to the 81 members and guests of the Metropolitan Section who attended the meeting in the A. W. A. Clubhouse in New York City on the evening of Nov. 19. Emphasis was placed on the advantages of light weight in motorcoaches, motor-trucks and passenger-cars, and the presentation of the paper was supplemented by numerous lantern slides showing the construction of an all-aluminum passenger-car and a number of its principal parts, as well as recent applications of aluminum to motorcoach and motor-truck construction.

## Service Station Policies Debated at Boston Meeting

H. BERTRAM LEWIS, vice-president of the Commercial Credit Co., of New York City, was the speaker at the November meeting of the New England Section, held the night of the 19th at the Hotel Kenmore, in Boston. He outlined to the 150 members and guests present 13 considerations that enter into the formation of a complete, sound service policy.

An interesting feature of the meeting was the round-table discussion on different phases of service. Many questions and answers brought out much information from the viewpoints of the service manager, distributor, dealer and garage management.

# Notes and Reviews

## AIRCRAFT

**Span-Load Distribution as a Factor in Stability in Roll.** By Montgomery Knight and Richard W. Noyes. Report No. 393. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 17 pp., illustrated. Price, 10 cents. [A-1]

This report gives the results of pressure-distribution tests made to study the effects on lateral stability of changing the span-load distribution on a rectangular monoplane-wing model of a fairly thick section. Three methods of changing the distribution were employed: variation in profile along the span to a thin symmetrical section at the tip, twist from + 5 to — 15 deg. at the tip, and sweepback from + 20 to — 20 deg. The tests were conducted at the Langley Memorial Aeronautical Laboratory in the 5-ft. closed-throat atmospheric wind-tunnel.

The investigation shows the following outstanding results:

(1) Change in profile along the span from the N.A.C.A. 84 at the root to the N.A.C.A. — M2 at the tip considerably reduces lateral instability, but also reduces the general effectiveness of the wing.

(2) Washout up to 11 deg. progressively reduces the maximum lateral instability.

(3) Transition from sweepforward to sweepback gradually reduces the useful angle-of-attack range, but has no clearly defined effect on the maximum lateral instability.

**The Drag Characteristics of Several Airships Determined by Deceleration Tests.** By F. L. Thompson and H. W. Kirschbaum. Report No. 397. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 15 pp., with tables and charts. Price, 10 cents. [A-1]

The results of deceleration tests conducted for the purpose of determining the drag characteristics of six airships are given herein. The tests were made during the last few years with airships of various shapes and sizes belonging to the Army, the Navy and the Goodyear-Zeppelin Corp. In each instance a representative of the National Advisory Committee for Aeronautics cooperated with the organization to which the airship belonged to conduct the tests. Although the deceleration tests with the U. S. S. Los Angeles have previously been reported, the final results obtained with that airship are included herein for comparison.

Drag coefficients for the following airships are shown: Army TC-6, TC-10 and TE-2; Navy Los Angeles and ZMC-2; Goodyear Puritan. The coefficients vary from about 0.045 for the small, blunt airships to 0.023 for the relatively large, slender Los Angeles. This variation may be due to a combination of effects, but the most important of these is probably that of the length-diameter ratio.

[1] See Effect of Variation of Chord and Span of Ailerons on Rolling and Yawing Moments at Several Angles of Pitch, by R. H. Heald, D. H. Strother and B. H. Monish. National Advisory Committee for Aeronautics Technical Report No. 343, 1929.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects As a rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H. Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

**The Aerodynamic Characteristics of Six Commonly Used Airfoils Over a Large Range of Positive and Negative Angles of Attack.** By Raymond F. Anderson. Technical Note No. 397. Published by the National Advisory Committee for Aeronautics, City of Washington, November, 1931; 5 pp., 6 figs. [A-1]

This paper presents the results of tests of six commonly used airfoils: the M-6, the CYH, the N-22, the C-72, the Boeing 106 and the Göttingen 398. The lifts, drags and pitching moments of the airfoils were measured through a large range of positive and negative angles of attack. The tests were made in the variable-density wind-tunnel of the National Advisory Committee for Aeronautics at a large value of the Reynolds number. For the N-22, the C-72, the Boeing 106 and the Göttingen 398 airfoils, the negative maximum-lift coefficients were found to be approximately one-half the positive; but for the M-6 and the CYH, which have less effective camber, the negative values were, respectively, 0.8 and 0.6 of the positive values.

**Lift Distribution and Longitudinal Stability of an Airplane.** By Carl Töpfer. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Vol. 22, No. 12, June 29, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 641; 7 pp., 4 figs. [A-1]

**Flutter in Propeller Blades.** By Friedrich Seewald. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Vol. 22, No. 12, June 29, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 642; 15 pp., 3 figs. [A-1]

**Load Assumptions for the Landing Impact of Seaplanes.** By Josef Taub. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Vol. 22, No. 14, July 28, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 643, 29 pp., 4 figs. [A-1]

**Relations Between Ship Design and Seaplane Design.** By Georg Schnadel. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Vol. 22, No. 15, Aug. 14, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 645; 10 pp., 7 figs. [A-1]

The foregoing four Technical Memoranda were issued during October and November, 1931, by the National Advisory Committee for Aeronautics, City of Washington.

**Control of Airplanes at Low Speeds by Means of Conventional Ailerons.** Aeronautics Bulletin No. 15. United States Department of Commerce. Published by the Government Printing Office, City of Washington, 1931. [A-1]

It has been suggested[1] that the use of only the upward displacements of the ailerons as a means of improving lateral control at high angles offers advantages that appear to warrant further study. To summarize briefly: The principal advantage is a very considerable reduction in the yawing moment due directly to the ailerons and, as a consequence of the smaller yawing velocities, a reduction of the rolling moment due to yawing. The rolling moment due to yawing opposes the normal rolling moment produced by the ailerons and results in a loss in effectiveness. This sequence of events is of special importance in the neighborhood of the stalling angle, since it is in this region that the ailerons as ordinarily used have already lost a large part of their effectiveness and lateral control can least be sacrificed.

The most obvious disadvantage in the use of upward displacements alone is the loss in rolling moment normally produced by the downgoing aileron. This must be compensated for by increasing the aileron area or travel, or possibly both. The increased loss of lift accompanying such changes gives rise to a second and possibly more serious objection, and measurements of this effect are in progress. A third objection arises from the increased hinge moments as compared with those accompanying conventional aileron rigging, but it seems probable that this condition can be met by suitable balancing.

**Beanspruchung von Flugzeuflügeln durch Böen.** By Hans Georg Küssner. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Oct. 14 1931, p. 579. [A-1]

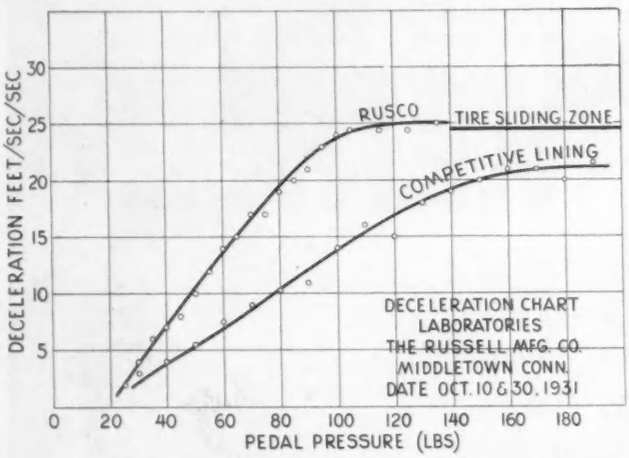
(*Continued on next left-hand page*)

KERITE
In 1752 Franklin invented the Lightning Conductor and identified lightning and electricity. A century later, Day invented
KERITE
Three-quarters of a century of experience has identified it as the most reliable and permanent insulation for Electrical Conductors
DAY'S KERITE
THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO SAN FRANCISCO

# WHAT RATIO
## PEDAL PRESSURE *vs.* DECELERATION

● **Both from the standpoint of safety and ease of driving, correct ratio of pedal pressure to deceleration is of vital importance in motor car brakes.**

**Rusco Brake linings can be adapted to any type of brake to provide maximum stopping power at any desired pedal pressure, with minimum danger of skidding in emergencies.**




Data: Weight of car, 3,065 lbs. Drum size, 11.500. Drum material, steel. Brake lining mileage (Rusco), 1,486; competitive lining, 2,851. Tire size, 4.75 x 19. Weather, clear; temperature, 65°; road, cement—both tests. Decelerometer, Bendix. Pressure Gauge, Bendix. Brakes fully adjusted and equalized before both tests. Name of car on request.

**The accompanying deceleration chart shows the difference between the action of Rusco Lining and a competitive lining on a light weight car, under varying pedal pressures. At a speed of 20 M.P.H. and a pedal pressure of 60 lbs. Rusco gave a deceleration of 14 ft. per second—compared to only 7 ft. with the other lining—100% quicker braking. Equally noteworthy, a maximum deceleration of 24 ft. per second per second was attained with Rusco under pedal pressure of 100 lbs. Yet, as shown by the flattening of the curve at higher pedal pressure, the possibility of skidding in emergencies is greatly reduced.**

**Complete charts showing pedal pressure, deceleration, fade-out and other performance data on Rusco Brake Linings for your brake will gladly be furnished upon request. Address Engineering Department B75, The Russell Manufacturing Co., Middletown, Conn.**

# RUSCO
## BRAKE LININGS


# *Notes and Reviews*
*Continued*

What are the stresses on aircraft wings due to squalls or gusts? The answer to this question was sought in the investigation reported in this technical note of the German Institute for Aeronautical Research.

Observations and measurements as to wind velocities during gusts are summarized. For the purpose of this investigation, wing-stress measurements on Junkers F-13 and G-25 aircraft were made during flights through storms. The extreme stresses felt over a number of flying hours are reported, as are also examples of the greatest variations in stress over a short period.

A theoretical investigation shows that the greatest stresses are due to vertical gusts and evaluates the effect on stresses of the intensity and variation of gust strength, of aircraft speed and of wing elasticity.

**Auswertung Experimenteller Untersuchungen über Luftschrauben mit Verdrehbaren Flügelblättern.** By H. Reissner and Melitta Schiller. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Sept. 28, 1931, p. 551. **[A-1]**

The adjustable-pitch propeller is the subject of this technical note of the German Institute for Aeronautical Research. The experimental results obtained by the National Advisory Committee for Aeronautics and by F. W. Caldwell, as reported in S.A.E. JOURNAL, are reduced to common terms. On this basis, a method is developed which is said to make possible the choice of the correct propeller form and the determination of the gain to be expected through adjustability.

**Around the World in Eight Days.** By Wiley Post and Harold Gatty. Introduction by Will Rogers. Published by Rand McNally & Co., Chicago, New York and San Francisco, 1931; 304 pp. **[A-3]**

To the engineer, the Post-Gatty world circuit was a twofold triumph: the demonstration of a new system of aerial navigation and of the ability of an aircraft and its powerplant to withstand an endurance run of unusual length, subject to climatic conditions of extreme severity and range of variation. To the philosopher, it was even more: a supreme achievement of cooperative human effort.

Both aspects of the flight are illuminatingly dealt with in this book, which is a day-by-day account of the astounding trip, the authors alternating in writing the various chapters. Two extremely likable personalities are revealed; of unpretentious and matter-of-fact but never foolhardy courage, of rugged hardihood and, most satisfying of all, of welcome and enjoyable humor.

Sufficient technical information is given to render the book of genuine engineering interest, yet not enough to rob it of readability and its character as a human document. Information is given on the design, loading, care and performance of the Winnie Mae. Only an extended and detailed treatise could give a complete explanation of the system of navigation followed, but Mr. Gatty tells enough to enable those who have some knowledge of the art to form a general idea as to his methods.

Autobiographical notes of Post and Gatty, a life history of the Winnie Mae and facsimiles of the pages in the log book kept during the world circuit are included as supplements to the story of the flight itself.

**The Department of Commerce and Safety in Aeronautics.** By the Hon. Clarence M. Young. Paper presented at the 20th Annual Safety Congress and Exposition, Chicago, Oct. 12 to 16, 1931. **[A-4]**

Under the provisions of the Air Commerce Act of 1926, the office of Assistant Secretary of Commerce for Aeronautics was created and the Aeronautics Branch was organized to administer the details of the Act. The foremost thought in the minds of those chosen to carry out these duties was safety, which now is the watchword of the branch.

The activities are discussed in the order in which they have been assigned to the three major divisions of the Aeronautics Branch: the Air Regulation Service, the Airways Division and the Aeronautic Development Service.

The regulation of aeronautics is divided into three main groupings: inspection service, licensing division, and engine-testing section.

Examination and licensing of pilots and mechanics, rating of flying-school instructors; inspection and approval of aircraft, flying-schools and aircraft repair stations, and regulation of scheduled interstate passenger airlines, are the outstanding duties of the inspection service.

The licensing division, among other activities, issues and renews aircraft and airman licenses, examines student pilots as to

*(Continued on next left-hand page)*

# Contact Bridge

## makes a *Grand Slam* with engine and motor car builders

# *Super* DRAINOIL

Has the correct number of properly spaced contact bridges —

The Contact Bridges provide

→ additional bearing surface ←
→ eliminate extravagant wear ←
→ prevent distortion ←

SUPER-DRAINOIL is Standard Equipment in

Brockway Truck
Buda Engine
Chrysler Six
Chrysler Eight
Chrysler Imperial
Chrysler Marine
Continental Motors
DeSoto Six
DeSoto Eight
DeVaux
Dodge Six
Dodge Eight
Dodge Truck
Durant Six
Essex
Federal Truck
Gray Marine
Hall-Scott Motors
Hudson
Indiana Truck
Nash Eight "70"
Plymouth
Reo Eight "21"
Willys Six
Willys-Knight "66-D"
Willys-Knight "95"

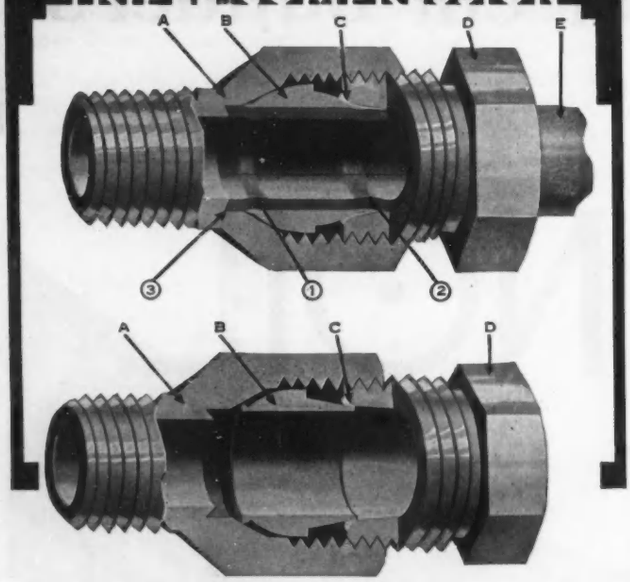
The Piston Ring Co., Muskegon, Michigan

ANNOUNCING

Dole

UNIVERSAL ALL-TUBE COUPLING

TRIPLE COMPRESSION




WITHOUT TUBING – BEFORE COMPRESSION

(1) First Compression
(2) Second Compression
(3) Third Compression

Patented February 3, 1931 No. 1,791,121

(A) Body
(B) Sleeve
(C) Solder Bearing
(D) Nut
(E) Seamed Tubing

*Approved by the Underwriters Laboratories*

HERE is the result of supreme engineering effort and experience to provide a single type of compression coupling to fit universally all seamed or seamless tubing of steel, aluminum, brass or copper. It is no longer necessary to depend upon couplings of various designs and construction for joining differently constructed kinds of tubing.

This Dole Universal All-Tube Coupling of two piece design surpasses all for joining to seamed or seamless tubing—for safety against leakage—for holding under all strain and vibration—for simplicity of connection—no separate sleeves—no flaring—no soldering—for reconnecting speedily and without limit—*for ultimate satisfaction and economy.*

The coupling consists of only the body and the threaded sleeve screw. Repeated connecting will not reduce the efficiency. Finger turned except for the compression turn. The solder which holds the sleeve on to the nut is sheared off during compression, thus giving a lead lubricated bearing—an exclusive Dole feature.

*Our engineering department will be pleased to work with you in the application of Dole Universal All-Tube Couplings. Cut open samples will be sent free upon request.*

THE DOLE VALVE COMPANY

1913-33 Carroll Avenue Chicago, Illinois, U. S. A.


# *Notes and Reviews*

*Continued*

their physical fitness for flying before they are licensed and periodically checks the physical condition of those who are already licensed. This division also handles the legal phases of enforcing the Air Commerce Regulations, investigates violations of the Air Commerce Act, the Air Commerce Regulations and the Air Traffic Rules, and investigates the causes of civil-aircraft accidents. The engine-testing section conducts tests of aircraft engines which are to be used in licensed aircraft.

Two other papers on the subject of safety in aeronautics presented at the Safety Congress were: Safety at Airports, by R. B. Barnitz, and Safety in Aeronautical Factories, by Ralph S. Damon.

## ENGINES

**Penetration and Duration of Fuel Sprays from a Pump Injection System.** By A. M. Rothrock and E. T. Marsh. Technical Note No. 395. Published by the National Advisory Committee for Aeronautics, City of Washington, October, 1931; 16 pp., 23 figs. **[E-1]**

High-speed motion pictures were taken of individual fuel sprays from a pump-injection system. The changes in the spray-tip penetration with changes in the pump speed, injection-valve opening and closing pressures, discharge-orifice area, injection-tube length and diameter, and pump throttle setting were measured. The pump was used with and without a check-valve. In addition, the effects of the variables on the time lag and duration of injection were determined with an oscilloscope. The results show that the penetration of the spray tip, the time lag of injection and the duration of injection can be controlled by the dimensions of the injection tube, the area of the discharge orifice and the injection-valve opening and closing pressures.

**Flame Movement and Pressure Development in an Engine Cylinder.** By Charles F. Marvin, Jr., and Robert D. Best. Report No. 399. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 12 pp., with tables and charts. Price, 10 cents. **[E-1]**

This investigation, which was conducted at the Bureau of Standards at the request and with the financial assistance of the National Advisory Committee for Aeronautics, describes a visual method for making stroboscopic observations, through a large number of small windows, of the spread of flame throughout the combustion-chamber of a gasoline engine. Data secured by this method on a small engine burning gaseous fuels are given to show the effects of mixture ratio, spark advance, engine speed, charge density, degree of dilution, compression ratio and fuel composition upon flame movement in the cylinder. Partial indicator diagrams showing pressure development during the combustion period are included. Although present knowledge is not sufficient to permit qualitative evaluation of the separate effects on flame movement of chemical reaction velocity, thermal expansion of burned gases, resonance, turbulence and piston movement, the qualitative influence of certain of these factors on some of the diagrams is indicated.

**On Atomization in Carbureters.** By F. N. Scheubel. Translated from Jahrbuch der Wissenschaftlichen Gesellschaft für Luftfahrt, 1927. Technical Memorandum No. 644. Published by the National Advisory Committee for Aeronautics, City of Washington, October, 1931; 10 pp., 8 figs. **[E-1]**

The foregoing Technical Memorandum was issued in October.

**Dispersion of Sprays in Solid-Injection Oil Engines.** By Kalman J. DeJuhasz. Paper presented at the National Oil and Gas Power Meeting of the American Society of Mechanical Engineers, at Madison, Wis., June 23 to 26, 1931. **[E-1]**

Control over the combustion in a solid-injection oil engine through division of the fuel charge is considered under two headings. First, the injected fuel must be divided into sufficiently small particles, thereby making available a large surface upon which the chemical reaction with the oxygen of the combustion air can take place. This process, called atomization, is the essential prerequisite of complete and rapid burning. Second, these particles must be mixed with, and distributed evenly in, the combustion air so that combustion can proceed without waste of fuel or air and at high loads. This process, called dispersion, is a fundamental requirement for low fuel consumption and high mean effective pressure.

The author describes experiments relating to spray dispersion from which he draws the following general conclusions: (*a*) The

(*Continued on next left-hand page*)

# The buyer who keeps coming back . . but NOT to buy!

You know him. The fellow who's tickled to death with his new car—for the first few days.

Then he comes back complaining about a body squeak. You put a mechanic on the job. A squirt of oil—the turn of a wrench—and the squeak is gone.

But not for long. The customer keeps coming back. At every trip, his irritation mounts—and so does your free service cost. Gone is all his bubbling enthusiasm for that shiny new car—and gone, very often, is a future sale for you.

• • • • •

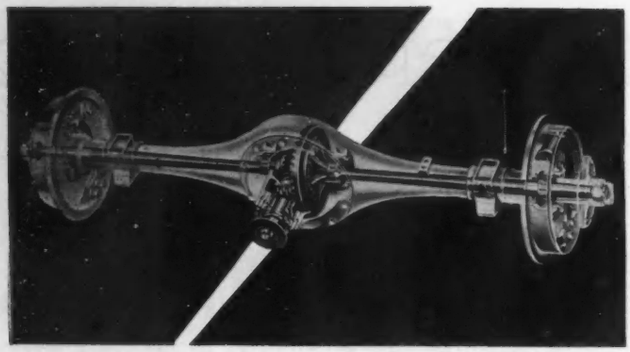
When an automobile body has no joints, there can be no squeaks—no rattles. Budd has eliminated joints by eliminating parts and by the extensive use of flash-welding. The Budd All-Steel one-piece body is made of only eight major parts — flash-welded into one single, jointless unit.

Originated by Budd engineers, this type of construction insures a degree of silence impossible in any other type of body.

Many dealers find that the Budd one-piece body eliminates free service cost on "squeaks and squawks". And, over and above this saving, its quietness is a help in selling cars—and in keeping them sold.

# ★BODIES BY BUDD★

Originators of the All-Steel Body. Supplied to Manufacturers in the United States, Great Britain, France and Germany



SALISBURY AXLES

Price is no barrier to obtaining the unusual quietness and dependability of Salisbury Axles. The same standard of manufacture prevails regardless of price. Their leadership is acknowledged by manufacturers in all price classes.

Their enviable position has been attained by 28 years of precision methods of manufacture combined with the finest materials and workmanship.

The engineering service that has helped establish their prestige is available to all manufacturers of cars, trucks and buses. Its use involves no obligation.

Spicer
MANUFACTURING CORPORATION
TOLEDO, OHIO

BROWN-LIPE CLUTCHES and TRANSMISSIONS
SPICER UNIVERSAL JOINTS
SALISBURY FRONT and REAR AXLES

# Notes and Reviews
*Continued*

dispersion becomes more even when the injection pressure is increased, the oil viscosity is decreased and the air density is increased; (*b*) the cone angle increases with increasing oil pressure, increasing air density and decreasing viscosity of oil; (*c*) a larger percentage of oil reaches a given distance in a spray having a more slender spray cone; (*d*) no definite trend was noticeable in using cylindrical orifices of the dimensions employed in the tests discussed.

That the experimental method described and the procedure of evaluation developed are easy to apply, and that the results give a ready means of judging the spray with reference to its applicability in an engine, are emphasized.

**Development of a High-Speed L-Head Diesel Engine.** By Max Hofmann. Paper presented at the National Oil and Gas Power Meeting of the American Society of Mechanical Engineers, at Madison, Wis., June 23 to 26, 1931. **[E-1]**

The author, in reviewing the history of solid-injection compression-ignition engines, points out that the present phase of development of the high-speed Diesel engine bears a remarkable similarity to that period of the gasoline engine when all kinds of combustion-chamber designs were popular. He suggests that the problem of designing high-speed Diesel engines that will stand up under continued operation may be solved by intelligently applying the experience gained with carbureter engines; by strengthening the vital parts sufficiently so that their unit loads and stresses on the Diesel engine are no higher than those that have proved to be safe on gasoline engines.

Mr. Hofmann describes in detail a new high-speed Diesel engine, developed by the Waukesha Motor Co., which represents a rather radical departure from present designs.

**Versuche mit Heisskühlung am Flugmotor.** By Hanns Weidinger. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Sept. 28, 1931, p. 541. **[E-1]**

High-temperature liquid-cooling, characterized as an intermediate step between water and air-cooling, was the subject of the research here described, during which both laboratory and flight tests were made.

Ethylene glycol, used as the cooling medium, is said to have one disadvantage, that of inflammability, but the risk from this source is thought to be small. The anti-freeze property of ethylene glycol is mentioned as a decided advantage.

From the viewpoint of engine operation, no objections to the use of high-temperature cooling were developed. The efficiency loss was small, especially when the cooling temperature was held below 293 deg. fahr., which is said to be, in general, the most suitable temperature. The engine showed itself equal to the thermal stresses involved.

The decrease in radiator size, with consequent lessening in weight and air resistance, made possible by high-temperature cooling, is emphasized as an important benefit. Even further gains than are indicated by the mere decrease in the bulk of the cooling system may be achieved, since the smaller radiator can be incorporated more harmoniously in the streamlines of the airplane.

A point which is said to need further investigation is whether high-temperature cooling makes imperative the use of a higher grade of fuel.

**Forschungen über Schwerölmotoren in den Vereinigten Staaten.** By William F. Joachim. Published in *Zeitschrift des Vereines Deutscher Ingenieure*, Jan. 17, 1931, p. 69. **[E-1]**

A comprehensive, well-organized and carefully compiled summary of research on oil engines in the United States is contained in this article presented before the Berlin World Power Conference.

Among the more important topics reviewed are: the development of a series of three-dimensional diagrams with the aid of which the economy and efficiency of a Diesel engine at different altitudes and under different climatic conditions can be determined; the relation of fuel-injection methods to engine efficiency, with the specific comparison of three different methods; nozzle design and spray forms; indicators and other instruments developed for the study of oil engines; and vibration and noise reduction. A special type of three-piston two-stroke-cycle engine is described.

The institutions whose oil-engine research constitutes the material of this article are the National Advisory Committee for Aeronautics, the Pennsylvania State College, the Massachusetts Institute of Technology and 14 industrial laboratories.

(*Continued on next left-hand page*)

# How Pierce-Arrow made sure the Motoring Public gets what it wants

Most motorists now prefer steel wheels. Some motorists still prefer artillery wheels. Pierce-Arrow, aware of both these facts, made the new Budd-Michelin Steel Artillery Wheel special equipment on current Pierce-Arrow models.

On these models, the beauty of this new Budd-Michelin Wheel shows to good advantage. But beauty is not its only virtue. It is six pounds lighter than an equivalent wood wheel. In lateral tests, it proves to be four to five times stronger. And it permits better decoration at less cost.

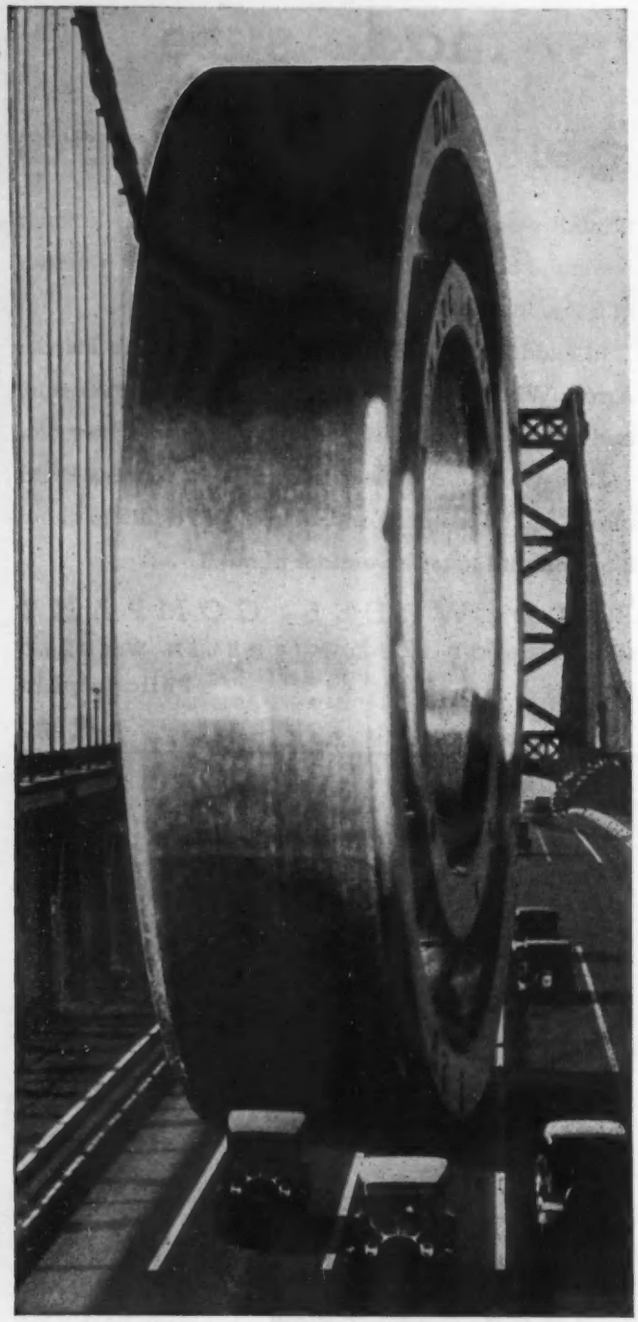
In low-carbon steel, this wheel can be given a natural wood finish—or can be finished with lacquer the same as the body. This makes finishing a matter of hours instead of days.

In stainless steel (the material used in the Pierce-Arrow Wheel), it harmonizes with any color scheme, and enhances the brilliance and richness of any car.

This new Budd Wheel is on display in the Budd plants in Philadelphia and Detroit. We'd like to show it to you and to tell you more about it.

BUDD WHEEL COMPANY
MAKERS OF BUDD-MICHELIN WHEELS
Detroit Philadelphia

★WHEELS BY BUDD★



**B. C. A.** Annular Bearings are manufactured from HIGH CHROME HIGH CARBON STEELS. Every bearing rigidly inspected for accuracy and precision.

BEARINGS COMPANY OF AMERICA
LANCASTER, PA.
DETROIT MICH. OFFICE: 1012 FORD BLDG.

# Notes and Reviews

*Continued*

**Methode zur Messung der Klopfgeräusche in Verbrennungskraftmaschinen.** By Professor Wawrziniok. Published in *Automobiltechnische Zeitschrift*, Aug. 20-31, p. 544, Sept. 10, p. 572, and Oct. 10, 1931, p. 652. **[E-1]**

After referring briefly to the investigation being made on detonation testing by the German society for testing materials, the author points out the fallacy of depending on the human ear for determining knock intensity. Errors of 100 per cent, he asserts, may be attributable to the variation in the hearing of experimenters. Curves showing the limits of audibility of tones of various frequencies are reproduced.

Vibration of the cylinder-head, due to the impact of the pressure wave, is said to cause the sound of detonation. The apparatus developed by the automotive department of the engineering college at Dresden for determining the intensity of detonation is then described. It consists of a microphone for the detection of sound, an amplifier and a photographic recording cathode-ray oscillograph. Besides the line showing sound intensity, the recording strip has indicated on it time intervals and the ignition and dead-center points.

Examples of test records are given, together with explanations of their significance. Future tests will attempt to determine for various fuels the relationship between the time at which detonation begins and the ignition point, as well as knock intensity.

**Internal-Combustion Engines.** By J. A. Polson. Published by John Wiley & Sons, Inc., New York City and London, 1931; 475 pp., illustrated. **[E-3]**

The author states that this book was prepared for use by junior and senior mechanical engineers in engineering colleges and universities who have had a rigid course in fundamental thermodynamics and who have gained from laboratory contact some conception of the construction of internal-combustion engines.

The Otto and Diesel cycles are first described and developed, following in both cases the plan of first describing and illustrating the cycle before taking up the theoretical development.

The theoretical development is treated by the familiar air-standard constant-specific-heat method and the variable-specific-heat method. Following this discussion, performance and test data are presented and analyzed.

Only American practice is considered. Typical examples and a few problems are given at various points in the text.

**The Comparative Performance of Diesel and Gasoline Engines in Motor-Trucks.** By P. Langer. Paper presented at the National Oil and Gas Power Meeting of the American Society of Mechanical Engineers, at Madison, Wis., June 23 to 26, 1931. **[E-4]**

In contrasting the internal-combustion engine with the Diesel engine for use as a prime mover in vehicles, the author points out that the weakness of internal-combustion engines is in operation at low speeds. He insists that the characteristic curves of both Diesel and gasoline engines show their advantages at high speeds, but these are usually limited to a minimum of about 300 r.p.m., below which no provision is made for the highly important range of low speeds.

In the investigation reported on in this paper, particular attention was paid to the performance of engines in the lowest speed-ranges. It embraced Diesel automotive engines working, with fuel-pumps, on heavy oil upon the fuel-combustion principles at present most widely employed in vehicle propulsion, and also gasoline carbureter engines, all of the engines studied being mounted in motor-trucks.

The study included engine-acceleration tests, measurement of maximum pressures during combustion, and road-acceleration tests, from which the author draws a number of conclusions.

## MATERIAL

**Hardness of Chromium as Determined by the Vickers-Brinell, Bierbaum, and Mohs Methods.** By Richard Schneidewind. Paper presented before the 13th annual convention of the American Society for Steel Treating, Boston, Sept. 21 to 25, 1931. **[G-1]**

The hardness of electrodeposited chromium was found to be 625 Brinell, 8 on the Mohs scale, and gave a scratch width of 2 microns with the Bierbaum microcharacter. Heating at 290 deg. cent. caused a sudden drop in hardness, due probably to the volatilization of hydrogen. After this treatment it was found to be 250 Brinell, 5.5 on the Mohs scale, and gave a scratch width of 4.15 microns with the Bierbaum apparatus. Further heating

(*Continued on next left-hand page*)

# AN IMPORTANT DECISION

## *concerning Chromium Plating*

of vital interest to every present and potential user of the chromium plating process

ON OCTOBER 20TH, 1931, there was rendered by Judge Edwin S. Thomas, of the District Court of the United States, an Opinion which is of vital interest to every individual or concern who is now practicing, or may contemplate the practice of, the art of commercial chromium plating.

THIS COURT held valid and infringed all claims in suit of U.S. Patent 1,581,188 granted April 20th, 1926 to Colin G. Fink and now owned by UNITED CHROMIUM, INCORPORATED, saying in part, as follows:

> "*In view of what has been said supra, all claims in suit are held valid and not inspired by the prior publications or by the prior art and not anticipated by the alleged prior uses.*"

COPIES OF the complete text of the Opinion are available to those interested.

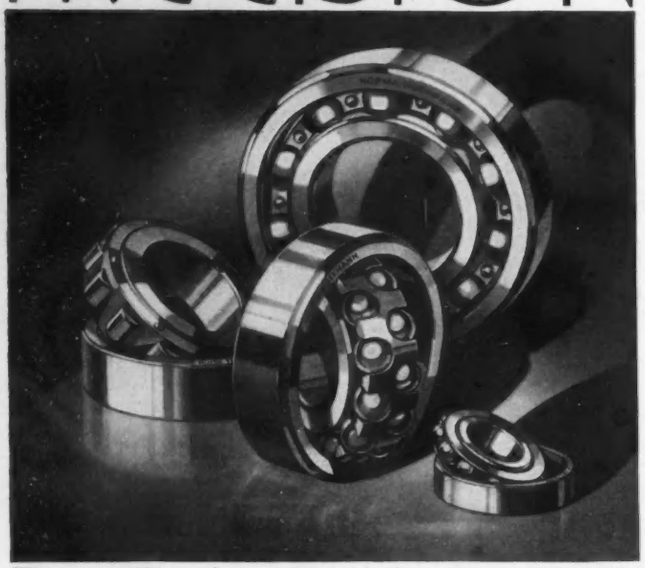
UNITED CHROMIUM, INCORPORATED will continue the policy of Licensing under its patents.

UNITED CHROMIUM, INCORPORATED

*Executive Office:* 51 East 42nd Street, New York City

DETROIT SAN FRANCISCO WATERBURY

PRECISION



BEARINGS

PRECISION—as the term defining the characteristics distinctive of NORMA-HOFFMANN Bearings—comprehends ALL those qualities which reveal themselves in higher anti-friction efficiency, greater speed-ability, better performance, longer life, fewer replacements, improved production.*** These are the definite and tangible gains which accrue to the builder and user of any machine in which NORMA-HOFFMANN PRECISION Bearings are incorporated.*** Herein lies the commercial value of the PRECISION which describes NORMA-HOFFMANN standards.*** Write for the PRECISION Bearing Catalogs.

"NORMA-HOFFMANN"
PRECISION BEARINGS
BALL, ROLLER AND THRUST

NORMA-HOFFMANN BEARINGS CORP., STAMFORD, CONN., U. S. A.

# *Notes and Reviews*

***Continued***

at 1050 deg. cent. caused the hardness to drop to about 135 Brinell, 4.5 on the Mohs scale, and gave a Bierbaum scratch width of 5.5 microns.

No exact relationships could be found between hardness of metals as measured by the three methods mentioned, although the logarithms of the Brinell and Mohs hardnesses for pure annealed metals seem to be related fairly well.

**The Phenomenon of Tensile Yield in Mild Steel and Iron.** By J. G. Docherty and F. W. Thorne. Published in *Engineering*, Sept. 4, 1931, p. 295. **[G-1]**

The object of the experiments described, which were made in the engineering laboratory of the Royal Naval College at Greenwich, England, was to determine the conditions under which the real phenomena of yield can be studied with standard apparatus. The fact has long been recognized, the authors state, that a drop of stress occurs at the yield point, and in recent years a number of experiments have been made in England and abroad to ascertain the magnitude of the drop. In some cases, autographic records show a small reduction of stress, while some experimenters, with specially designed apparatus, record as much as 30 per cent.

In the laboratory and test-house, under usual conditions, it is very unusual to record anything in the nature of a drop of stress. Yield, or permanent set, occurs at comparatively low stresses and progresses slowly. When this permanent set has reached an arbitrarily agreed amount, or, alternatively, the specimen continues to elongate without increase of load, the yield point is said to have been reached. This state of affairs gives rise to very inconsistent values of the yield point as determined by different experimenters. Much of the difficulty in reconciling published data arises from this lack of a precise definition of yield point.

As the present experiments were confined to mild steel and iron, much of the dubiety disappears, but some still remains. For these materials, two distinct yield points can be recognized; namely, (*a*) a "higher yield point" at which yield begins, and (*b*) a "lower yield point" at which yield continues.

**Symposium on Abrasion Testing of Rubber.** Given at the 34th annual meeting of the American Society for Testing Materials, Chicago, June 22 to 26, 1931. Published as a reprint from the *Proceedings of the American Society for Testing Materials*, Philadelphia; Vol. 31, Part II, 1931; 62 pp., illustrated. **[G-1]**

This symposium was planned to bring together the information collected on abrasion testing and was arranged to cover other subjects of interest such as (*a*) notes on the correlation of service tests with laboratory tests, (*b*) unusual service conditions and results, (*c*) design of an ideal abrasion machine and (*d*) tearing and cutting tests and their value in determining abrasion resistance. The following papers are included, the first of which compares results in the laboratory with road tests on several tire-tread compounds:

Abrasion Tests of Vulcanized-Rubber Compounds Using an Angle Abrasion Machine, by J. L. Tronson and A. W. Carpenter.

Study of a Test for Tear Resistance of Vulcanized-Rubber Compounds, by A. W. Carpenter and Z. E. Sargisson.

The Measurement of the Work Done in Punching a Rubber Cylinder from a Test Sheet, by H. A. Depew, S. I. Hammond and E. G. Snyder.

Abrasion Testing of Rubber with Bureau of Standards Type Machine, by W. E. Glancy.

Comparative Tests of Four Abrasion Machines, by C. A. Klaman.

Discussion on Abrasion Testing of Rubber.

**The Present Position of Knock-Testing Standardization. Standard Fuels.** By C. H. Barton. **Engine Types and the C.F.R. Standard Engine.** By C. H. Sprake. **Methods of Test and Precautions To Be Observed.** By R. Stansfield. Published in the *Journal of the Institution of Petroleum Technologists*, Aug., 1931, p. 468. **[G-1]**

These three articles constitute a résumé of the work done to date on the subject of knock rating of motor fuels. The three authors are members of the Standardization Subcommittee of the Institution of Petroleum Technologists in Great Britain which is working in cooperation with the Subcommittee on Methods of Measuring Detonation of the Cooperative Fuel-Research Steering Committee here in America.

Mr. Barton deals with the subject of Standard Fuels, pointing out how the need for them arose and what has been decided upon by the cooperating committees. Mr. Sprake deals with the subject of the Standard Engine, describing the various types of engine

(*Continued on next left-hand page*)

# BECAUSE OF THIS SPIRIT

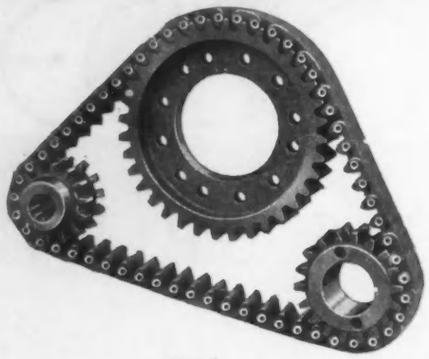
THE biggest thing about your telephone is the spirit of the hundreds of thousands of people who make up the Bell System. No matter what their particular jobs may be, they are first of all telephone men and women.

The loyalty of these people to the ideals of their work is reflected in every phase of your telephone service. It shows in the increasing speed with which your local and long distance calls are completed. It shows in the greater accuracy with which they are handled. It shows in the wider and more convenient facilities which are placed at your command—extension telephones, intercommunicating systems for home and office, small and large switchboards, teletypewriters and many others.

Because of this spirit, your needs for fast, complete and inexpensive telephone service are more fully met each year. Men and women of the Bell System are constantly explaining the varied telephone services to more and more users. They prepare the way for the new plant and equipment put at your disposal every year. Through their efforts, you receive better and wider service at a cost made possible only by an organization of this character.

Although it does not appear on the balance sheet, the greatest asset of the Bell System lies in the skill, energy and purpose of the people who carry on its work. Every time you telephone, you get the advantage of this—in better and better service at the lowest possible cost.

★ *AMERICAN TELEPHONE AND TELEGRAPH COMPANY* ★



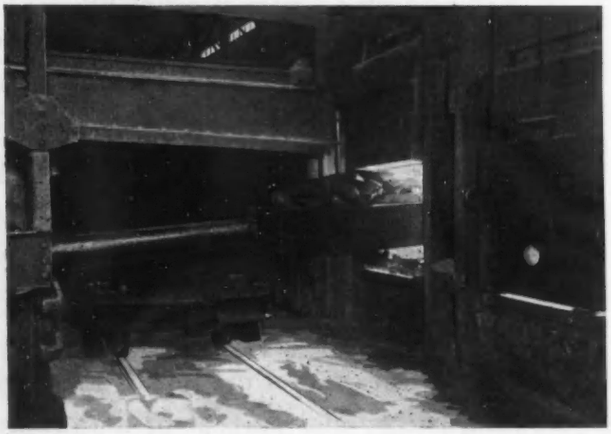
The
WHITNEY
Silent Timing Chain

is satisfactorily quiet and smooth in operation, durable and positive in action. Its original features are covered by patents.

THE WHITNEY MFG. CO.
Hartford, Conn.

Manufacturers of Silent Chain for over twenty years and Roller Chain for over thirty years.

COMPLETE SUITABILITY



TO YOUR PARTICULAR TASK

If alloy steel is to render the utmost performance under any given set of conditions, the particular requirements of the intended service must be kept in view at every stage of manufacture.

This condition obtains to a very high degree in the Bethlehem Alloy Steel Plant. The men responsible for the control of the processes of manufacture have specialized in handling every operation in such a way as to contribute to the ability of the steel to perform satisfactorily the task for which it is intended.

BETHLEHEM STEEL COMPANY
*General Offices:* Bethlehem, Pa.

BETHLEHEM
ALLOY STEELS

# *Notes and Reviews*

*Continued*

and pointing out why the C.F.R. engine was selected; finally, Mr. Stansfield gives a short exposition on the standardization of a test method.

**La Transformation des Carbures d'Hydrogène Gazeux en Carbures d'Hydrogène Liquides.** By A. Mailhe. Published in *La Technique Moderne*, Sept. 1, p. 581, and Sept. 15, 1931, p. 621. **[G-1]**

The fears emphatically expressed several years ago that a shortage of petroleum fuels would confront the world in a few years are said herein to appear to be ill-founded. However, synthetic fuels are still of interest to countries which, like France, have no natural-petroleum resources, and the most promising method of manufacture is stated to be the transformation of industrial hydrocarbon gases into liquids.

A history of experimentation along this line is given, with a brief account of methods employed and results obtained. The gases treated are acetylene, methane, ethylene and related substances. The methods used comprise reduction by the application of heat, of heat under pressure or heat in the presence of a catalyzer. Methane seems to be the most promising raw material, and its supply, from a number of natural resources, is abundant.

**Le Cinquième Rallye des Carburants Nationaux.** Published in *A.C.F.*, October, 1931, p. 3. **[G-1]**

Almost six years of contact with the propaganda for the French national fuels rallies has convinced the writer of the foreword to this report that the primary significance of such events is military. The test runs and the investigations attendant upon them have shown that France has within her boundaries a large potential supply of fuel sufficient to meet the wartime needs of a motorized army should supplies from the outside be cut off.

To make such fuels available in usable form during a crisis will require a large supply organization, and a skeleton of such organization should be maintained in peace times as a preparedness measure, the author asserts. In his opinion, these so-called national fuels should be developed to compete commercially with petroleum products only insofar as this can be done without interfering with fiscal returns from taxation on imported fuels. National fuels should be developed where such action constitutes a needed support to some other industry, as, for instance, the use of alcohol has contributed to the prosperity of certain branches of agriculture. A difficulty in the way of wartime use of the fuels so far developed is that some of them, notably those of alcohol and benzol bases, contain ingredients needed for the manufacture of ammunition.

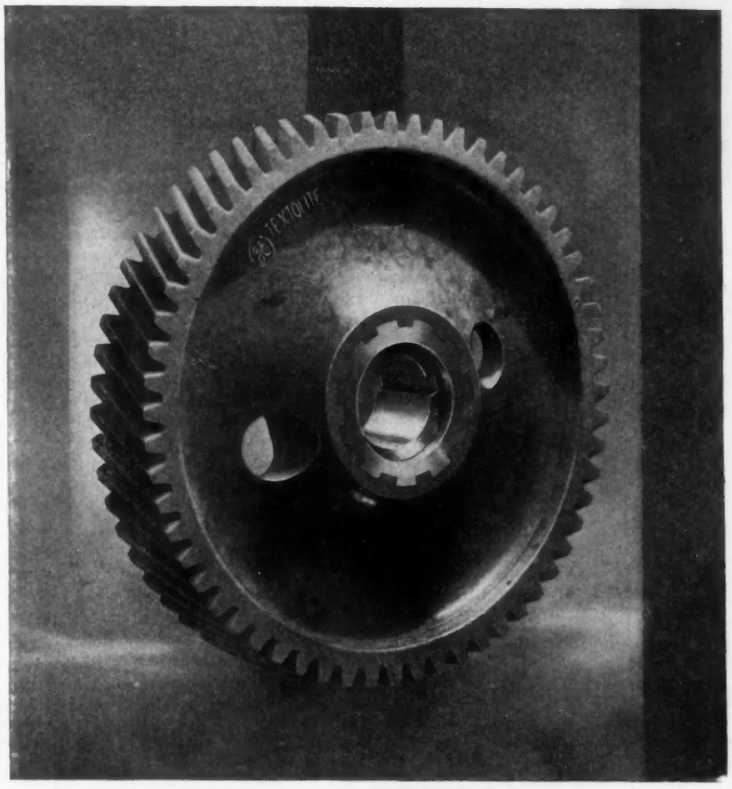
The national fuels rally took the form, as usual, of a tour, this year extending from July 5 to 23, and following an Alpine route of 2287 km. (1421 miles). In the report proper, detailed information is given on the performance of the entries, divided into three classes: those using liquid fuels, for the most part alcohol, benzol or naphthalene blends, and Diesels using gas oils; those charged with gas producers, with wood or charcoal as the prime fuel; and those operating on compressed gas.

**Relationship between Volatility and Consumption of Lubricating Oils in Internal-Combustion Engines.** By Gustav Wade and A. L. Foster. United States Bureau of Mines Technical Paper 500. Published by the Government Printing Office, City of Washington, 1931; Price 10 cents. **[G-4]**

Four petroleum-producing regions in the United States—the Appalachian, Mid-Continent, Gulf Coast, and California—are the major sources of lubricants for automotive engines. For a given viscosity, oils made from typical crudes of each of these regions differ considerably in volatility characteristics. For this reason most of the work reported in this paper was done on four lubricating oils that are typical of the oils produced from these major regions. Other specially prepared or blended oils were used for particular phases of the study, as detailed in the body of the paper. The study was made in the experimental laboratory of the United States Bureau of Mines at San Francisco. The dynamometer tests ended in January, 1928, and subsequent laboratory work was completed in December, 1928.

The general plan of the work was: (*a*) To determine the physical and chemical characteristics of the oils by the customary tests; (*b*) to test each oil in the engine for a definite period of time under definite and, so far as feasible, uniform running conditions, noting particularly any evidences of superior or inferior service performance; and (*c*) at the end of each run, to determine the quantity of oil consumed in the test and the extent of change in the physical and chemical characteristics of the oil used.

(*Continued on next left-hand page*)



# Only Gears can maintain crankshaft and camshaft in perfect timing

CORRECT timing demands that crankshaft and camshaft be maintained precisely in their initially perfect relationship.

The average wear in a nonmetallic timing gear is less than .001 in. per 20,000 miles, so that displacement of camshaft and crankshaft is infinitesimal.

Adjustment of "adjustable" types of camshaft drives does not reëstablish this initially perfect relationship between crankshaft and camshaft—it merely takes up slack caused by wear.

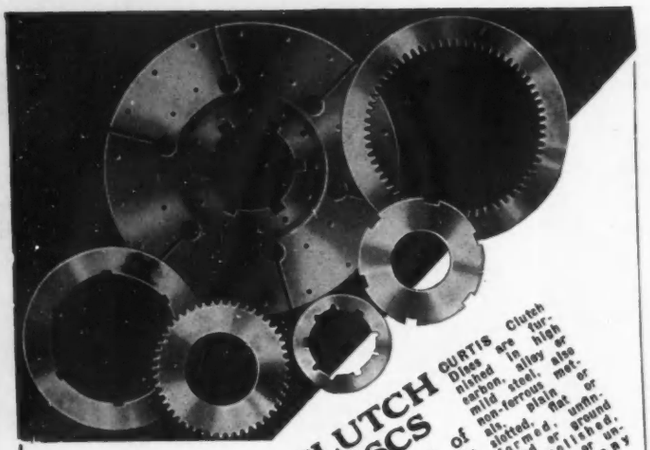
Properly installed nonmetallic gears are good for 50,000 miles of quiet service, without adjustment—in fact there is nothing to adjust.

**TEXTOLITE TIMING GEARS**

830-110

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES



CURTIS CLUTCH DISCS

Only long experience in the manufacture of Clutch Discs can tell a manufacturer what is necessary for satisfactory performance in automobile, truck or tractor service.

This company has concentrated its efforts for years on the manufacture of custom-built Clutch Discs of precision. The result of that skilled experience shows in the perfection of its finished product.

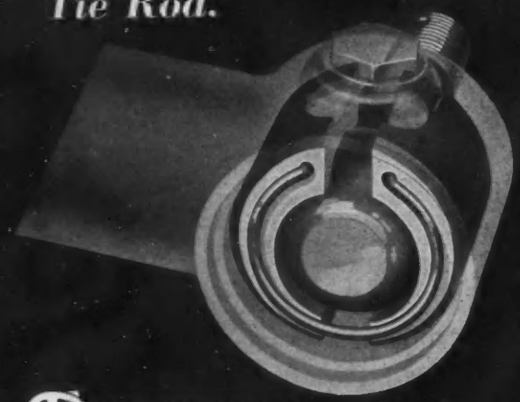
And because of solving so many perplexing problems in this field, the Curtis Company is particularly qualified to give expert advice as to your particular needs. Correspondence is invited.

CURTIS CLUTCH DISC CO.
Division of Curtis Manufacturing Company
1956 Klenlen Ave.
St. Louis, Mo.

CURTIS Clutch Discs are furnished in high carbon, alloy or mild steel, also non-ferrous metals, plain flat or slotted, unformed, ground and polished, or unhardened or tempered, any size.

UTMOST SIMPLICITY

*There are only four parts within the socket of the Thompson Eccentric Tie Rod.*



Thompson Eccentric Tie Rods

# *Notes and Reviews*

*(Continued)*

The authors emphasize that the results obtained in this study apply strictly only to the oils, engine and operating conditions used in the work. With other oils, another engine and different operating conditions the results probably would have been different.

**Heat-Treatment Fundamentals of Plain and Alloy Cast Iron.** By F. B. Coyle. Published in *Metals and Alloys*, Sept., 1931, p. 120. **[G-5]**

The author discusses the nature and structure of cast iron and the effect of heat upon it and continues with a consideration of the forms of heat-treatment that have been most extensively adopted by various industries, giving particular attention to the processes of artificial aging and annealing to facilitate machining.

The more recently adopted quenching, or quenching followed by drawback, which has been adopted for certain specific purposes, is also considered at some length by the author, who expresses the opinion that the possibilities are promising and an interesting field for extension of the applications of cast iron in industry presents itself as a fertile possibility.

## MISCELLANEOUS

**A New Principle of Sound-Frequency Analysis.** By Theodore Theodorsen. Report No. 395. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 15 pp., illustrated. Price, 15 cents. **[H-1]**

In connection with a study of aircraft and propeller noises, the National Advisory Committee for Aeronautics has developed an instrument for sound-frequency analysis which differs fundamentally from previous types and which, owing to its simplicity of principle, construction, and operation, has proved to be of value in this investigation. The method is based on the well-known fact that the ohmic loss in an electrical resistance is equal to the sum of the losses of the harmonic components of a complex wave, except for the case in which any two components approach or attain vectorial identity, in which case the ohmic loss is increased by a definite amount.

An automatic recording instrument embodying this principle is described in detail. It employs a beat-frequency oscillator as a source of variable frequency. A large number of experiments have verified the predicted superiority of the method. A number of representative records are presented.

**1931 Book of A.S.T.M. Tentative Standards.** Published by the American Society for Testing Materials, 1315 Spruce Street, Philadelphia, 1931; 1008 pp. **[H-3]**

The Book of A.S.T.M. Tentative Standards is an annual publication. The term "tentative" applies to a proposed standard published for one or more years, with a view to eliciting criticism, before it is formally adopted as standard by the society. In the 1931 edition, 44 of the tentative standards relate to metals and 136 to non-metallic materials and products. Although these tentative standards are in the trial stage of A.S.T.M. procedure, they represent the latest thoughts of the committees on these specific subjects and therefore are being applied in many industries.

**The Selection and Training of Vehicle Operators.** By Alvhh R. Lauer. Paper presented at the 20th Annual Safety Congress and Exposition, Chicago, Oct. 12 to 16, 1931. **[H-4]**

Professor Lauer, of the department of psychology, at Iowa State College, reviews briefly a three-year program of research conducted to seek out, describe and render serviceable the basic principles of a method of selecting and eliminating those who apply for motor-vehicle driver's licenses. He lists the principal classifications of personal factors that affect driving ability or contribute toward the causes of accidents and describes the study of possible methods for measuring or differentiating individuals with respect to these traits.

Other papers dealing with operator requirements, presented at the Safety Congress are:

What the Commercial-Vehicle Operator Requires of the Public and Private-Car Operator, by Emil A. Danneman.

What the State Requires of All Commercial-Vehicle Operators, by Robbins B. Stoeckel.

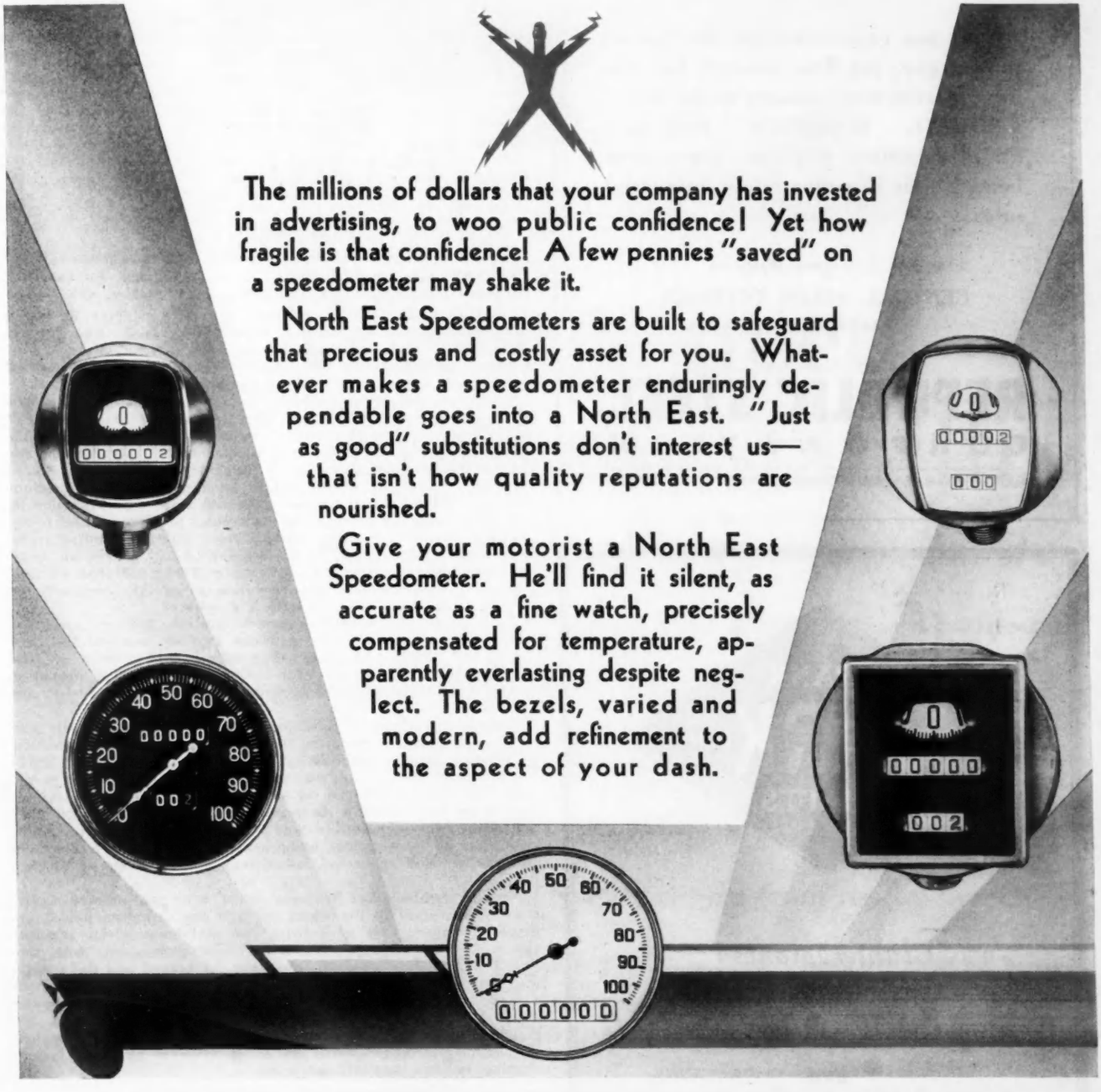
**La Résistance et le Calcul des Joints Soudés dans les Pièces Fléchies.** By D. Rosenthal. Published in *Le Génie Civil*, Oct. 3, p. 345, and Oct. 10, 1931, p. 364. **[H-5]**

The majority of tests on welded joints, states the author of this paper, have been limited to pieces submitted to the axial forces of tension and compression. The question he attempts to answer is how to give the welded joint the same strength against breakage under bending stress as the part itself. Tests

*(Continued on next left-hand page)*

# NORTH EAST

## S·P·E·E·D·O·M·E·T·E·R·S


The millions of dollars that your company has invested in advertising, to woo public confidence! Yet how fragile is that confidence! A few pennies "saved" on a speedometer may shake it.
North East Speedometers are built to safeguard that precious and costly asset for you. Whatever makes a speedometer enduringly dependable goes into a North East. "Just as good" substitutions don't interest us—that isn't how quality reputations are nourished.
Give your motorist a North East Speedometer. He'll find it silent, as accurate as a fine watch, precisely compensated for temperature, apparently everlasting despite neglect. The bezels, varied and modern, add refinement to the aspect of your dash.

DELCO APPLIANCE CORPORATION
ROCHESTER, N.Y., U.S.A.
STARTERS • GENERATORS • IGNITION • HEATERS • SPEEDOMETERS

ENDURO
REPUBLIC'S PERFECTED
STAINLESS STEEL

**Not too expensive for the lowest priced car, yet fine enough for the most distinctive custom made body. ENDURO, Republic's Perfected Stainless Steel, brings permanent beauty that is reflected in increased sales.**

*For Literature Write to*
**CENTRAL ALLOY DIVISION**
**MASSILLON, O.**

**REPUBLIC STEEL**
**CORPORATION**
GENERAL OFFICES YOUNGSTOWN, OHIO

CRANK
DROP PARK GUARANTEED FORGED
SHAFTS

*Counterbalanced*

**CRANK SHAFTS**
*and*
**Heavy Die Forgings**

THE PARK DROP FORGE COMPANY
*Cleveland, Ohio*

# *Notes and Reviews*
*Concluded*

made on joints welded by the Arco electric autogenous process are reported and conditions governing rupture are discussed. From the results of the investigation, rules for designing such joints are developed.

## MOTORCOACH

**Vehicle Maintenance—A Factor in Safe Distribution.** By Fred C. Oldham. Paper presented at the 20th Annual Safety Congress and Exposition, Chicago, Oct. 12 to 16, 1931. **[J-2]**

The author discusses in a general way the subject of motor-vehicle maintenance from a safety viewpoint and lists a number of typical cases from the records in which the cause of the accident, as given by either the driver or the garage mechanic who examined the car, was due to faulty steering mechanism. In conclusion, Mr. Oldham lists nine reasons why the fleet operator should be interested in accident prevention and adequate maintenance.

## PASSENGER CAR

**Le XXV^e Salon de l'Automobile.** By G. Delanghe. Published in *Le Génie Civil*, Oct. 17, p. 391, and Oct. 24, 1931, p. 420. **[L-1]**

That Great Britain is the only European country in which automotive production did not show a decrease during 1930 is one of the statements made by the author in the summary of recent developments in the industry. This summary is part of the regular annual review of the Paris automobile show.

In France the larger producers have been relatively unaffected by the depression, which has been felt keenly by the smaller manufacturers. The number of vehicles in operation has increased, although the number of applicants for examinations for drivers' licenses had fallen off. Exports from France to Spain, Germany, Italy and Great Britain have declined; but Belgium has imported a greater number of French cars. Specialization in the manufacture of accessories has become pronounced and fewer of these articles are being bought from foreign manufacturers. The number of used cars to be disposed of has become an acute problem, more of these having been sold in 1930 than of new products. One manufacturer now has a special showroom for rebuilt cars, which are sold with a guarantee.

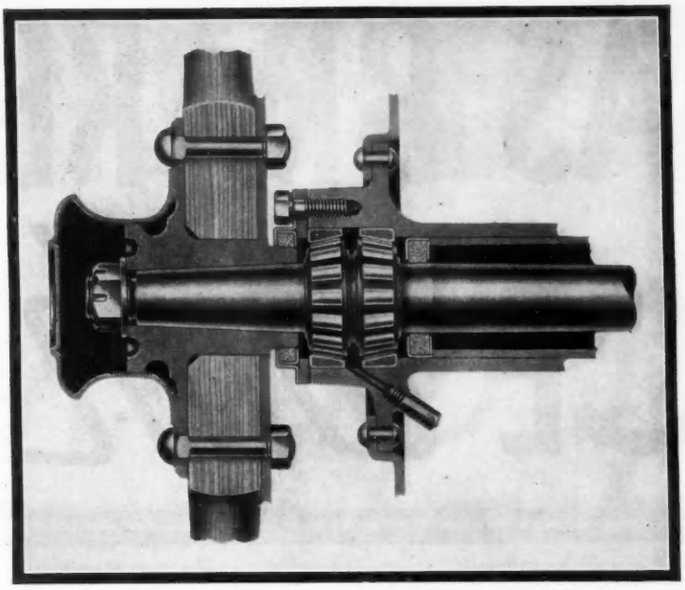
Development of the road system to meet the higher speeds and greater intensity of Traffic, and the growing accident toll, are mentioned briefly. The almost complete motorization of the army is described, and plans for developing cooperation instead of competition between the railroads and highway vehicles are outlined.

Because of economic conditions, issuance of new models has practically ceased. Attention has been focused on the perfection of existing models, heightening of comfort and luxury of body-work and the reduction of cost through the use of standard parts. However, the accentuation of certain new tendencies saves the 25th salon from being a mere re-edition of its predecessor. Independent wheel-suspension and front-wheel drive have made important gains, while the reappearance in France of free-wheeling has aroused again the controversy as to the merits of this device.

Among the technical features noted are: the marked favor shown in general to the small car and the emphasis placed on greater comfort, ease of driving and maintenance; in engines, the stationary status of the six-cylinder powerplant, with the four for utilitarian purposes, the eight for luxury and the twelve and sixteen for superluxury; the elimination and damping of vibration, the replacement of the gear front drive by the silent chain and the facilities provided for cold-starting; and, in transmissions, the common use of the four-speed transmission for luxury-type vehicles and the substitution of automatic gear-shifting for the conventional lever.

**Die Rationalisierung der Lackierverfahren des Automobilbaues der Adlerwerke.** By E. Jurthe. Published in *Automobiltechnische Zeitschrift*, Sept. 30, 1931, p. 601. **[L-5]**

A description is given of the equipment and methods for finishing with nitrocellulose lacquer at the Adler automobile factory. The equipment is designed to accommodate a production of 15,000 cars annually, with the observance of a 48-hr. week. A possible saving over the older finishing method of about 70 per cent is claimed. Other advantages are said to be better quality of finish, less factory space required and larger turnover, hence less capital investment.



Tapered Roller TIMKEN BEARING EQUIPPED

# Rear Wheels need Timken stability

Rear wheels have to carry a considerable part of the weight of the car and its passengers. That means a large *radial* load . . . But rear wheel responsibility does not end there. Rear wheels also have to carry *thrust* — thrust intensified by today's high speeds when rounding curves; shocks from road obstructions; sudden braking stresses; and the high torque of super-power motors . . . For stability and safety under all operating conditions rear wheels should be mounted on Timken Tapered Roller Bearings.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

**TIMKEN** *Tapered Roller* **BEARINGS**

# . . . HAS BRAKE KEPT PACE *with*

**Has Brake Protection kept pace with today's Free Wheeling?**
**Has Brake Protection kept pace with today's Traffic Problems?**
**Has Brake Protection kept pace with today's increase of women drivers?**

**These are questions that face every car manufacturer—every state safety council—every thinking motorist.**

**The insistent demand for speed—and yet more speed on the highways for motor cars—motor coaches—for trucks—has been successfully met. Engineers have been eminently victorious in re-designing motor cars and power plants to make possible higher and higher speeds.**

**—But has our zeal in the attainment of that goal made us unmindful of the responsibilities—of the new problems born of that speed?**

**We know the car manufacturer is acutely conscious of the situation today. He realizes that the power to go has outstripped the power to stop—and that the problem is intensified by the advent of FREE WHEELING, which puts the conventional brake in the spotlight, and reveals its inadequacy to meet present conditions.**

## Facing the New Trend in Safety Legislation

**The car manufacturer is facing these facts, recognized by the leading safety councils of the various states, and stated so tersely by one of them:**

> **"During the past few years, development of Motor Vehicles has been chiefly concerned with the attainment of greater driving speed. The trend of motor vehicle legislation and its enforcement has been to permit greater driving speeds on our highways. This trend, coupled with increasing congestion of traffic and the more prevalent use of 'free wheel-**

**STEWART-WARNER**

# PROTECTION *todays speeds?*

ing' devices, is in the direction of greater highway hazards, unless CORRESPONDING EFFORT is expended to improve the braking power available to the driver."

The manufacturer faces, too, the fact that all motorists are concerned about the high maintenance costs of Braking Systems not fitted to cope efficiently with the high speeds that now prevail.

## The Problem and Its Solution

The first step in the solution of the problem is a clear definition of the main objectives that must be attained. These are:

1. Power to stop quickly, which means a power of deceleration at least six times the power used to accelerate to a given speed.
2. Braking Power under the absolute control of the driver, which means an amplification of power in direct proportion to pedal pressure.

Brakes built on conventional principles fulfilled old driving conditions acceptably. But new conditions demand a new solution. The whole industry must disregard precedent. Let us face the facts frankly.

Brake Protection is a problem that deeply concerns all of us. For the good of the industry, therefore, let us consider it sincerely, earnestly, with open mind. We hope this discussion which we have opened in current trade magazines and which will be continued in succeeding issues, will prove beneficial to all.

**STEWART-WARNER CORPORATION**
Chicago, U. S. A.

**BRAKE SYSTEMS**

You can
*depend*
on
GIBSON
SPRINGS
and STAMPINGS

ANY TYPE OR MATERIAL

WM. D. GIBSON CO.
1800 Clybourn Ave., Chicago, Ill.

SEND FOR OUR CATALOG

SMALL DROP FORGINGS

Forged and Trimmed Only or Machined Complete
Modern Heat Treating Facilities
For All Grades of Steel

ALSO

| | |
|---|---|
| Common Carriage Bolts | Step Bolts |
| Eagle Carriage Bolts | Wrought Washers |
| Cold Punched Nuts | Machine Bolts |
| Small Rivets | Plow Bolts |
| Elevator Bolts | Hot Pressed Nuts |
| Lag Bolts | Turnbuckles |

The Columbus Bolt Works Co.
Columbus, Ohio

QUALITY :-: SERVICE

# *Personal Notes of the Members*

(*Continued from p.* 488)

newly formed Stearman-Varney Aircraft Co., of Alameda, Calif.

**Charles C. Fadenbauer** recently left the employment of John A. McCarthy & Co., of New York City, for which he was transportation superintendent, and assumed similar duties with the Gordon Baking Co., of Long Island City, N. Y.

**Alfred A. Gassner** gave up his position as chief engineer of the Fokker Aircraft Corp., of Hasbrouck Heights, N. J., when A. H. G. Fokker resigned as director of engineering of the General Aviation Corp. and reorganized the Fokker Aircraft Corp. Mr. Gassner is now acting as an independent aeronautic engineering consultant in New York City.

**William H. Higham,** having given up his position an engineer with the Bijur Lubricating Corp., of Long Island City, N. Y., is now serving the Vacuum Oil Co. of South Africa, Ltd., as fuel engineer. For the present he is located in New York City.

**Hans Hodgemann** has been engaged as a designer by the Edward G. Budd Mfg. Co., of Philadelphia. His former connection was with the Electro-Dynamic Co. of the Electric Boat Co., of Bayonne, N. J., as engineering draftsman.

**Arthur A. Howgrave** has severed his connection with the Dunlop Rubber Co. (India), Ltd., and accepted the appointment of district traffic superintendent of roads with H. E. H. The Nizam State Railways, with headquarters at Secunderabad, Deccan, India.

**L. J. Jursek** recently resigned his position as superintendent of tools and factory equipment for the Bundy Tubing Co., of Detroit. His plans for the future are indefinite.

**F. A. Keihn,** who has been sales engineer in the automotive car division of the J. G. Brill Co., of Philadelphia, since 1924, has been appointed sales engineer of the company and is now in charge of all sales engineering matters, reporting to Charles O. Guernsey, recently appointed chief engineer of the company.

Having resigned as sales manager of the Potter Mfg. Co., and president of Willeray Confections, Inc., of Jackson, Mich., **J. M. Kerr** is now affiliated with the Kelsey-Hayes Wheel Co., of Detroit. He is with the metal-stamping division sales department.

Having relinquished the position of experimental and layout man in the die room of the Chevrolet Motor Co., of Flint, Mich., **Karl Knohl** has assumed new duties as a designer with the Colonial Broach Co., of Detroit.

**Donald de Lackner,** formerly construction engineer with the Sikorsky Aviation Corp., of Bridgeport, Conn., is now a designer in the engineering department of the American Airplane & Engine Co., of Farmingdale, N. Y.

**Harry G. Lamker** has accepted appointment as foundry superintendent for the Wright Aeronautical Corp., of Paterson, N. J. He was formerly secretary-treasurer of the Alloys Foundry Corp., of West Paterson, N. J.

**Friedrich Wilhelm Lampe** has severed his connection with the Precision Balancing Machine Co., of Minneapolis, as experimental and mechanical engineer and is now experimental engineer in the Chevrolet experimental engineering laboratory of the General Motors Corp., in Detroit.

**Carleton John Lauer** now holds the post of experimental engineer with the A. C. Spark Plug Co., of Flint, Mich. He used to be chief engineer and manager of the refrigeration division of Brooks Steam Motors, Inc., of Buffalo.

**Robert P. Lay** is now connected with the National Transit Pump & Machine Co., of Oil City, Pa. His previous position was that of assistant chief engineer with the H. H. Franklin Mfg. Co., of Syracuse, N. Y.

(*Continued on next left-hand page*)

# FIRST SHOWING OF THE NEW MODELS

At The

32d National

# Auto Shows

**NEW YORK**
**Grand Central Palace**
**Jan. 9—16, 1932**

**CHICAGO**
**Coliseum**
**Jan. 30 to Feb. 6, 1932**

This winter's shows will be the most important, the most interesting ever held. The new models of 43 different makes of passenger cars, commercial cars and taxicabs will be displayed. A comprehensive showing of accessories and parts. The whole industry will be on parade. To keep in step with its progress, a visit to the shows is imperative. Don't miss them—they are a vital part of modern industrial life.

Shop Equipment sections, where the latest developments in service machinery and tools are to be shown, again will be a part of both shows. Open to the trade until 5 p.m., after which time the public will be admitted.

As usual, Trade Days are Monday and Tuesday of Show Week.

The Chicago Show will be open Sunday at 10 a.m.

*Auspices of National Automobile Chamber of Commerce, Inc., with the cooperation of Motor and Equipment Association.*

S. A. MILES, MANAGER, 366 MADISON AVE. - - NEW YORK CITY

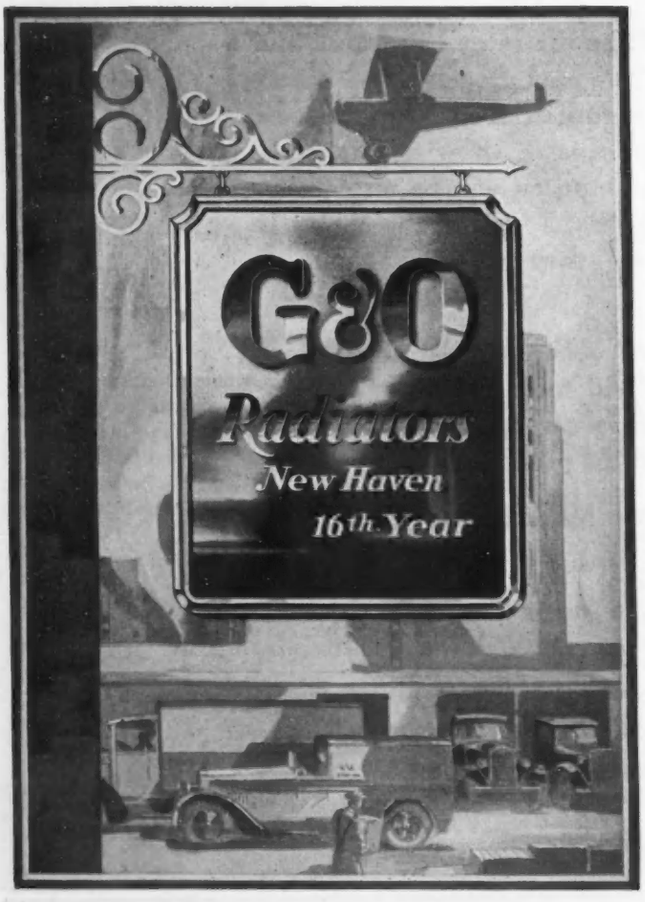
SPRING MAKERS FOR THREE GENERATIONS

WHEN you require cooperation in the design or other factors associated with the use of Springs, won't you take advantage of our special engineering resources?

*Competent Technicians*
*Practical Springmakers*
*Sample Spring Dept.*
*(Fully Equipped)*
*Testing Laboratories*
*(Chemical and Physical)*

THE WALLACE BARNES CO.
BRISTOL CONN.

Barnes-made Springs
SPRINGS ASSEMBLIES SCREW MACHINE PARTS
STAMPINGS SPRING WASHERS COLD ROLLED SPRING STEEL




# *Personal Notes of the Members*

*Continued*

**Snowden E. Lea** has become affiliated with the Twin Coach Co., of Kent, Ohio. He formerly had charge of service with the Pitcairn Aircraft, Inc., of Willow Grove, Pa.

**William J. Mayer**, formerly sales engineer for the Brockway Motor Truck Corp., of New York City, is now assistant to the chief engineer of the Edward G. Budd Mfg. Co., of Philadelphia.

**W. J. McVicker** is now general manager of W. J. McVicker & Son, consulting engineers, of Minneapolis, engaged in designing agricultural, industrial and automotive machinery. Before engaging in this work he was chief engineer of the threshers division of the Moline Power Implement Co., also of Minneapolis.

**Paul Miller** recently entered the employment of the Gray Marine Motor Co., of Detroit, as engine designer. His previous position was that of engineer with the H. E. Dodge Boat & Plane Co., of the same city.

**Yoshio Ogawa**, formerly owner of the Ogawa Co., of Daytona Beach, Fla., is now assistant general manager, in charge of service, with the Palama Auto Co., of Honolulu, T. H.

**C. E. Packer** is now connected with the educational service of the LaSalle Extension University, of Chicago, as a writer.

**Paul P. Pierce** has assumed new duties with the General Motors Truck Co., of Pontiac, Mich., as transportation survey engineer in the Boston district. He used to be an engineer in the refined-oil department of the Vacuum Oil Co., of New York City.

**John Pollitt, Jr.**, formerly proprietor of Pollitt & King, Liverpool, England, is now service garage manager of Joseph Lucas, Ltd., at Birmingham, England.

**D. G. Proudfoot** has relinquished his position as chief engineer in the western region for the Sun Oil Co., and has not announced his plans for the future. His address is 17159 Northlawn Avenue, Detroit.

**Beverly Bliss Puddy**, who was a student at the University of Toronto, is now a cost-accounting student with Robertson, Robertson, McCannell & Dick, chartered accountants, of Toronto, Canada.

**Fred Rath** has assumed the duties of die designer with the Briggs Mfg. Co., of Detroit. His previous position was that of tool designer for the Continental Motors Corp., of Muskegon, Mich.

Having severed his connection with the United Engineers & Constructors, of Philadelphia, **H. M. Rinehart** now serves the City and County of San Francisco, Calif., as field office engineer.

**Daniel Felix Ritchie**, having relinquished his position as equipment sales engineer for the Allis-Chalmers Mfg. Co., at Springfield, Ill., has accepted the position of designing engineer with the LaPlante Choate Mfg. Co., of Cedar Rapids, Iowa.

**Clifford E. Roberts** has accepted a position with the Consolidated Aircraft Corp., of Buffalo, as design engineer for military airplanes. His last position was that of a designer and checker of wings, with the Glenn L. Martin Co., of Middle River, Md.

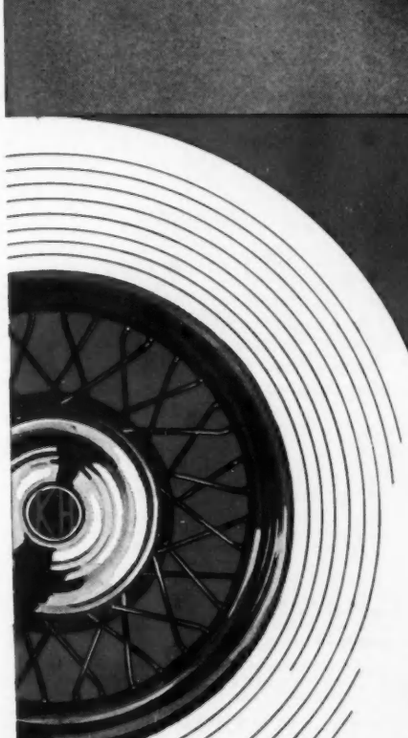
**Ralph N. Robertson** recently assumed the duties of chief engineer of the Atwood Bradshaw Corp., of Pittsburgh. His former connection was with the Blaw-Knox Co., of the same city, as mechanical engineer.

**George Travis Rolan**, until recently connected with the Cadillac technical service of the General Motors Products, Inc., of Oshawa, Ont., Canada, now handles public relations work for the Cadillac Motor Car Co., in Brooklyn, N. Y.

**Charles Sardou, Jr.**, has left the Stearman Aircraft Co., of Wichita, Kan., which he served as a junior engineer. His present address is 3135 West Euclid Avenue, Topeka, Kan.

(*Concluded on next left-hand page*)

# KELSEY-HAYES



## PLANT EQUIPMENT

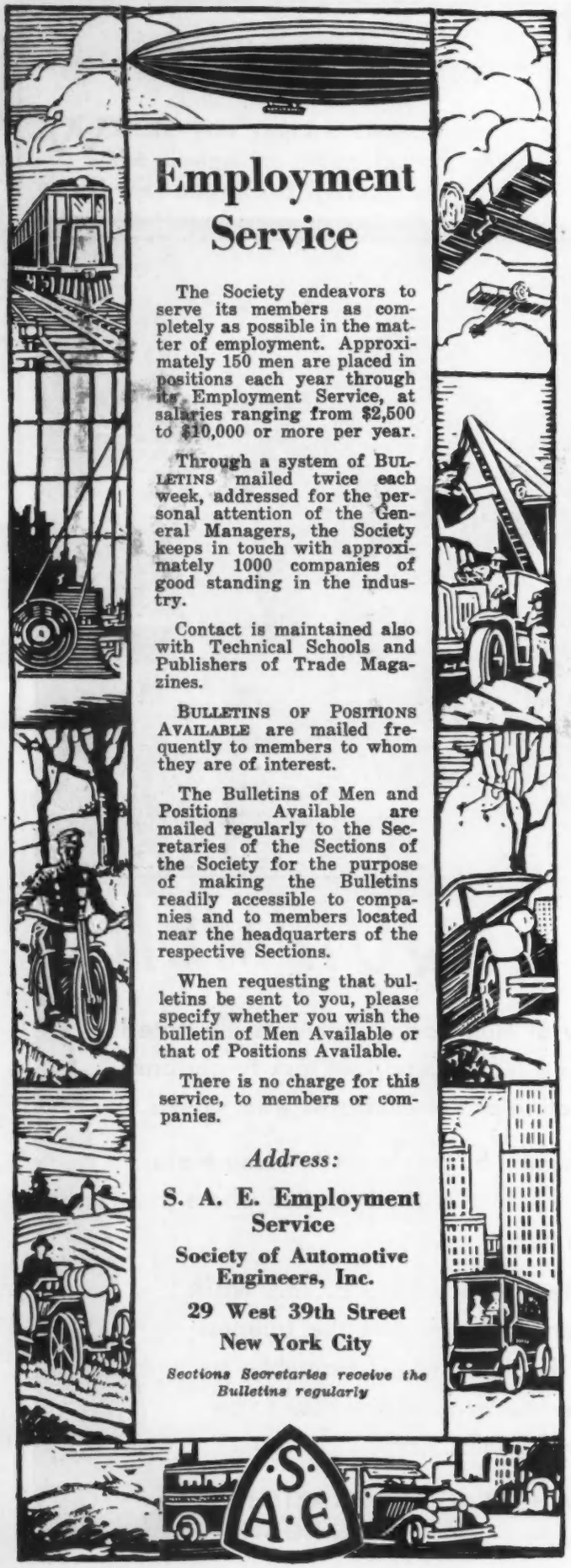
The battery of Hub Facing Machines illustrated herewith has a highly important task to perform in the fabricating of Kelsey-Hayes wire wheels.

The wheel is located by the rim on these machines and they face the seat of the hub shell where it sets against the hub.

On the accurate performance of this work depends to a very large degree the trueness and alignment of the entire wheel assembly, so many of these super-modern machines are to be found in Kelsey-Hayes plants.

KELSEY-HAYES WHEEL CORPORATION
DETROIT - - MICHIGAN

WOOD
WIRE
DISC
WHEELS



# Employment Service

The Society endeavors to serve its members as completely as possible in the matter of employment. Approximately 150 men are placed in positions each year through its Employment Service, at salaries ranging from $2,500 to $10,000 or more per year.

Through a system of BULLETINS mailed twice each week, addressed for the personal attention of the General Managers, the Society keeps in touch with approximately 1000 companies of good standing in the industry.

Contact is maintained also with Technical Schools and Publishers of Trade Magazines.

BULLETINS OF POSITIONS AVAILABLE are mailed frequently to members to whom they are of interest.

The Bulletins of Men and Positions Available are mailed regularly to the Secretaries of the Sections of the Society for the purpose of making the Bulletins readily accessible to companies and to members located near the headquarters of the respective Sections.

When requesting that bulletins be sent to you, please specify whether you wish the bulletin of Men Available or that of Positions Available.

There is no charge for this service, to members or companies.

*Address:*

**S. A. E. Employment Service**

**Society of Automotive Engineers, Inc.**

**29 West 39th Street**

**New York City**

*Sections Secretaries receive the Bulletins regularly*

# *Personal Notes of the Members*

*Concluded*

**Ben Schechter**, formerly chief engineer of the American Car Co., of St. Louis, is now trolley-bus engineer for the J. G. Brill Co., of Philadelphia.

Having relinquished his position of director of sales and engineering with the Climax Engineering Co., of Chicago, **Allen Conkling Staley** is now serving as engineer in the research division of the Chrysler Corp., of Detroit.

**E. Waldo Stein**, who held the position of development engineer with the Firestone Tire & Rubber Co., in Akron, Ohio, has been made resident engineer for the company in Detroit.

**Thomas Freemantle Turton**, who was sales manager for W. & G. DuCros, Ltd., of London, England, is now certifying officer with the Traffic Commissioners for the eastern area at Sidney House Sussex Street, Cambridge, England.

**T. A. Weir** has arranged to become fuel engineer for the Compagnie Industrielle des Pétroles, of Paris, France. He formerly was connected with the Vacuum Oil Co. as automotive engineer, with headquarters at Lisbon, Portugal.

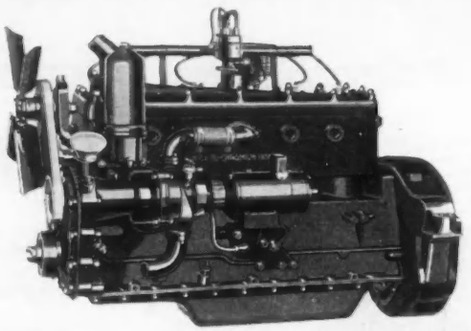
**Andrew M. White**, who formerly held a position as engineer in the Brooklyn, N. Y., office of the New York Telephone Co., is now a sales representative of the company.

**Harold F. Wood**, who has been chief metallurgist of the Ingalls-Sheppard division of the Wyman-Gordon Co., in Harvey, Ill., since 1920, has been advanced to the post of works manager of that division.

**H. Putnam Wood** has changed his connection from that of layout draftsman with the General Motors Truck Corp., of Pontiac, Mich., to that of layout draftsman with the Edward G. Budd Mfg. Co., of Detroit.

**Wallace E. Zierer** now holds the position of experimental engineer with the Chrysler Corp., of Detroit. He formerly was engineering statistician with the same company.


**GRADUATED POWER**



*The Continental Red Seal Engine Series E-600*

SPECIFICATIONS

| | Bore | Stroke | Displacement | H. P. |
|---|---|---|---|---|
| E-600 | 3 1/8 | 4 1/2 | 288 | 73 |
| E-601 | 3 3/8 | 4 1/2 | 318 | 80 |
| E-602 | 4 1/8 | 4 1/2 | 360 | 90 |
| E-603 | 4 1/4 | 4 1/2 | 382 | 98 |

The Continental E-600 six cylinder series for trucks offers unusual efficiency and economy of operation in a closely graduated power range. These engines, having the same installation dimensions, are interchangeable in engine mountings. Special "dry-gas" manifolding and cylinder head design provide unusual horsepower per pound of weight and per cubic inch of displacement. Cooling system provides ample flow of water around all cylinder barrels and around valves. Exhaust valve ports are completely jacketed. Gear driven pressure feed oil system to all wearing parts assures long life.

Provision is made for mounting every type of accessory individually or in combination—distributor, magneto, air cleaner, thermostat, oil filter, air compressor, 750-watt generator, velocity type governor.

At all speeds, unusually high power output is coupled with economical operation.

CONTINENTAL MOTORS CORPORATION

*Offices*: Detroit, Michigan, U.S.A.
*Factories*: Detroit and Muskegon

**Continental Engines**

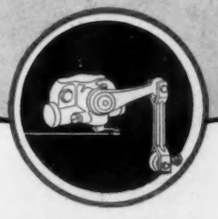
# *Ride Regulating Control*

## introduces new *ride appeal* in many 1932 car models

The most significant development in automobile riding comfort since the introduction of the Delco-Lovejoy Hydraulic Shock Absorber—soon will be introduced by several manufacturers of fine cars.

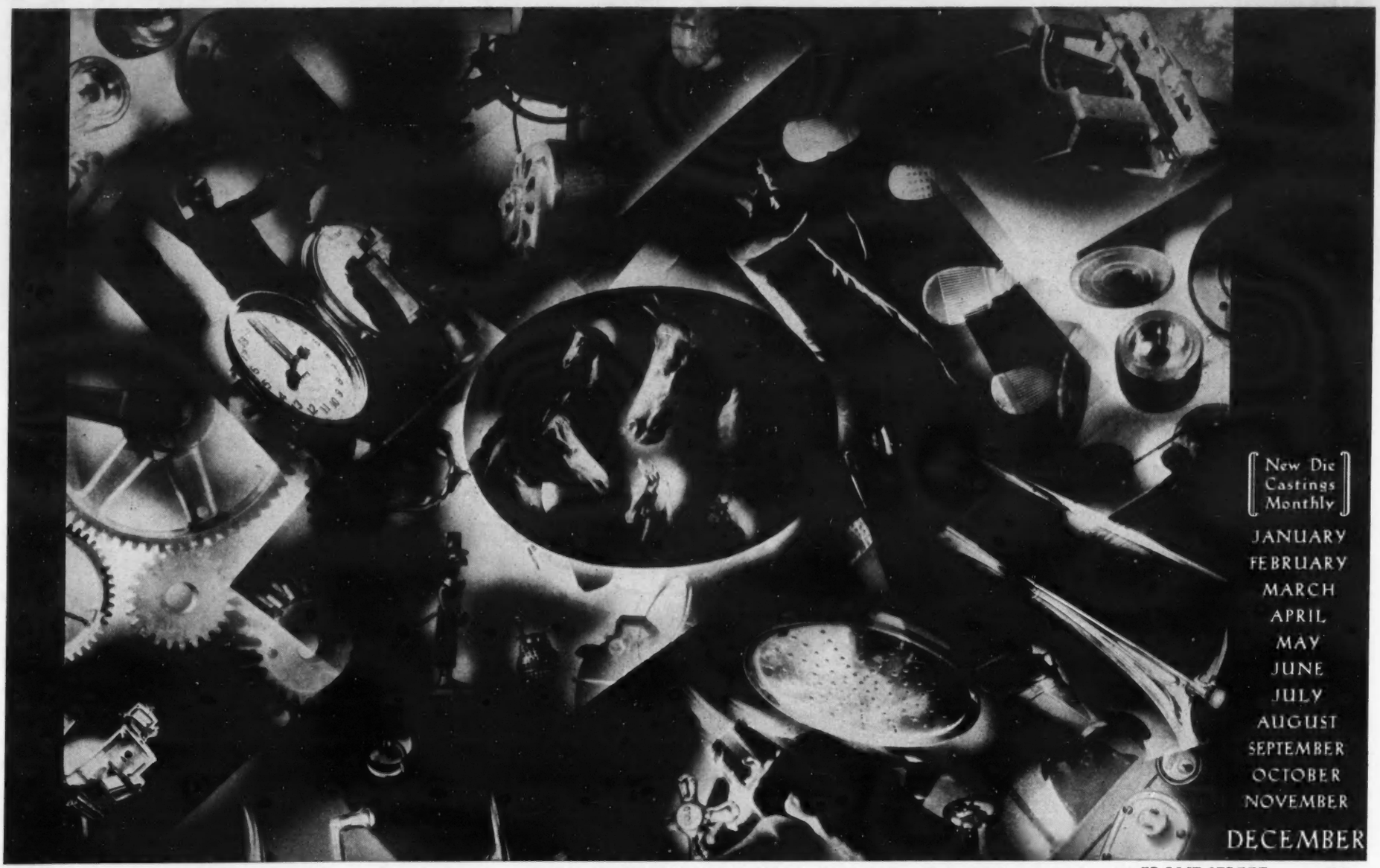
**DELCO** LOVEJOY·HYDRAULIC SHOCK·ABSORBERS

*REGULATED FROM THE DRIVER'S SEAT*



DELCO PRODUCTS CORPORATION · DAYTON, OHIO

# HORSE HEAD 99.99+% UNIFORM QUALITY ZINC FOR DIE CASTINGS




Zinc Metal Alloys ▪ Rolled Zinc ▪ Zinc Pigments
Sulphuric Acid ▪ Spiegeleisen

THE NEW JERSEY ZINC COMPANY

160 FRONT STREET
NEW YORK CITY

# Only if it is SAFE TO DRIVE

•

# will the public call it SAFE TO BUY . .

•

***A recent authoritative survey in which approximately 150,000 motorists were questioned showed that 45 per cent of all persons injured in motor car accidents were cut by flying glass.***

**There is an awakening apprehension on the part of the public. The Power and Speed of modern motor cars have been developed beyond the wildest dreams of a few short years ago. They have been emphasized so strongly in advertising and in direct sales efforts that a very natural reaction has set in.**

**The prospective purchaser now asks himself, "with all that power, all that speed, *is it Safe to utilize this amazing performance unless the car has every available protective feature?*"**

**Safety Glass as standard equipment is a very definite answer to that question. The manufacturers who offer it in current models not only capitalize upon a very evident public demand for this particular safety measure, but, by offering this outstanding safeguard, gain an extra sales advantage in that its inclusion definitely implies similar protective standards in every other respect.**

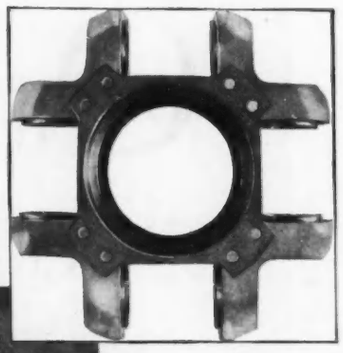
**L·O·F Safety Glass is a perfected product that is strong, clear and permanent. As a safeguard it is priceless. As a sales advantage, it is a recognized asset.**

LIBBEY-OWENS-FORD GLASS CO., TOLEDO, O., *manufacturers of Highest Quality Flat Drawn Window Glass, Polished Plate Glass and Safety Glass; also distributors of Figured and Wire Glass manufactured by the Blue Ridge Glass Corporation of Kingsport, Tenn.* . . . The following are users of L·O·F Safety Glass: Packard, Graham, Studebaker, Franklin, Reo, Willys, Willys-Knight, Ford, Cadillac and La Salle. It is also used in Dietrich and LeBaron Custom Bodies, Reo Speed Wagons, Paige Commercial Cars, Twin Coaches, Brill Trolley Buses, Cincinnati Trackless Trolley Coaches, Bender Bus Bodies, Hackney and Springfield School and Passenger Bus Bodies, White School Buses, York-Hoover School Bus Bodies, Stinson and Stearman Aircraft, Gar Wood Boats and Matthews Cruisers.

# LIBBEY·OWENS·FORD SAFETY GLASS

# The AUTOGIRO

© 1931, Autogiro Co. of America



ABOVE: Nickel-Chromium Steel rotor hub of Autogiro, mfd. by AUTOGIRO SPECIALTIES CO., Philadelphia, Pa. LOWER LEFT: Nickel Alloy Steel spar end fitting used in Autogiro. (Forgings by The Midvale Company). LEFT: Autogiro mfd. by PITCAIRN AIRCRAFT, INC., Willow Grove, Pa.

## ...with NICKEL STEEL

## *parts introduces a new era of air travel*

Marking a new development in aircraft design, the Autogiro embodies distinctive safety features which promise to revolutionize aeronautical construction. One of the most important parts of the Autogiro is the rotor with its horizontal revolving blades—a unique feature permitting the machine to hover almost stationary and to decend almost vertically.

Nickel Alloy Steel S.A.E. 3435 is specified by the Autogiro Specialties Company for the rotor hub and fittings. This hub must be especially strong and tough, since in flight it must withstand the centrifugal and torsional forces incident to the rotation of the blades, and must support the entire weight of the machine. Nickel Alloy Steels are also used in most of the highly stressed parts of the engine which powers the Autogiro, and Aerol landing gear struts with Nickel Steel cylinders are standard equipment.

Leading aviation engineers specify Nickel Alloy Steel wherever toughness, safety and dependability are essential. You are invited to consult with us regarding your problems in selecting Nickel Alloy Steels.

Nickel
ALLOY STEEL
PERFORMS BETTER LONGER

INCO NICKEL

Send for our publication, "The Curtiss and Wright Engines and Their Use of Nickel Alloy Steel"

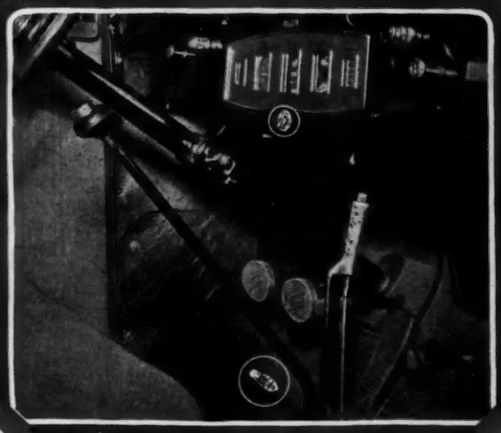
**THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.**

*Miners, refiners and rollers of Nickel. Sole producers of Monel Metal*

# CORRECT PRINCIPLE of LIGHT CONTROL

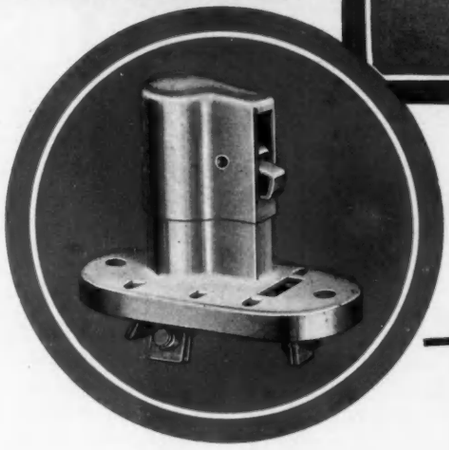
## foot control switch for chassis lights

CONTINUOUS LIGHT



## selective control switch for body lights

FROM DIM TO BRIGHT



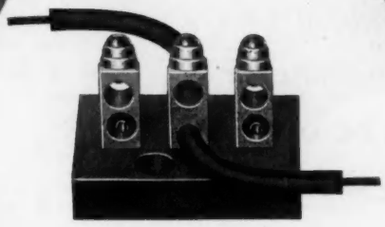
No. 5076

Just a slight push downward with the foot—and Presto—the head lights and tail light are switched on! Another push—and the dim lights are on! Another push—and the bright lights are back on! And there is a continuous light—no dark spots between—because the Dim is not off until the Bright is on—and the Bright is not off until the Dim is on!

Just a little push with the sole of the shoe on the "Off" switch —as shown on the right side of the switch pillar—and the lights are cut off! And all this with the most simple, yet durable construction! The breakdown test showed 1,800,000 operations!

## THESE TWO NEW SWITCHES

**Used with HAD Junction Blocks and Snap Terminals!**



## CUT YOUR INSTALLATION COST ONE HALF!

Yes, indeed, that's a pretty strong statement and we will welcome an opportunity to prove it. You can get both of these new HAD light control switches for the price of one ordinary type switch. Just drop us a line and we will gladly send you full details. Above all, we ask you to remember that our research and engineering departments may be of help in solving your particular lighting problems. This service is available to you.

No. 5074

And here is a brand new, body light, selective, control switch — with four positions — off, courtesy, park and dash—embodying the latest ideas in a simple, yet sturdy construction! It is positively trouble proof and fool proof! And built to last a lifetime!

In addition to the four-position switch, this same type of toggle switch is built with two and three positions, when desired—as, "Off-On" and "Courtesy-Off-Dash"!

*No dash switch required for tail light*
*Tail light is on - with head light or park light*

HAD **H. A. DOUGLAS MFG. CO.** HAD
BRONSON, MICH.

# "What make do they Prefer?"

Faced with the necessity of replacing original equipment, which way does today's car owner turn? What make or makes of tires, spark plugs, or shock absorbers does he seem *naturally* to prefer? What make of storage battery?

This should, we feel sure, be one of the biggest factors governing the selection of original equipment units.

There is a remarkably strong preference of car owners for one make of storage battery. Year in and year out they buy more Willards than any other make of battery.

To the 76 makers of cars, trucks, and busses who specify Willard batteries for original equipment this widespread public preference is an asset—and they are capitalizing on it.

*Willard Thread-Rubber insulation is made of vulcanized rubber reinforced with hard rubber ribs. It unites the electrical insulating value and durability of rubber with the uniform porosity of cotton threads. You can get it only in a Willard. All Thread-Rubber batteries are in genuine hard rubber containers.*

*Willard wood insulation is made only from first grade and genuine Port Orford cedar, the finest insulating wood known for batteries. These separators are cut exclusively from selected growths, are chemically treated in a process controlled by Willard Laboratories, and subjected to rigid tests and inspections before use.*

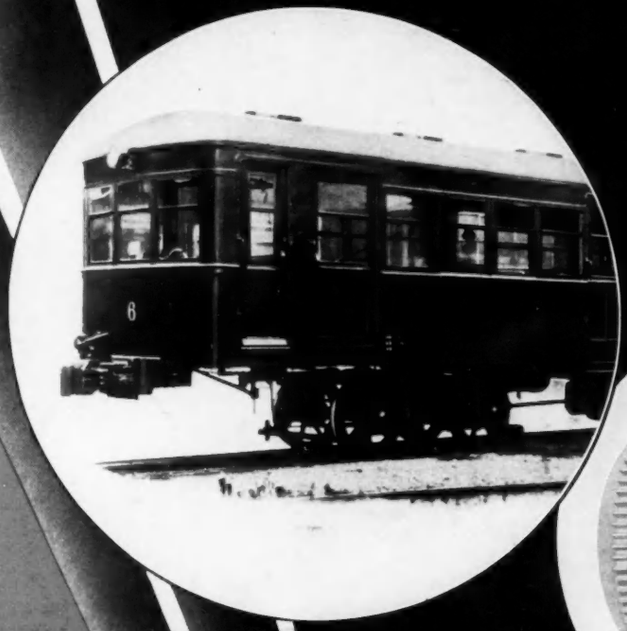
STORAGE BATTERIES

**Willard**

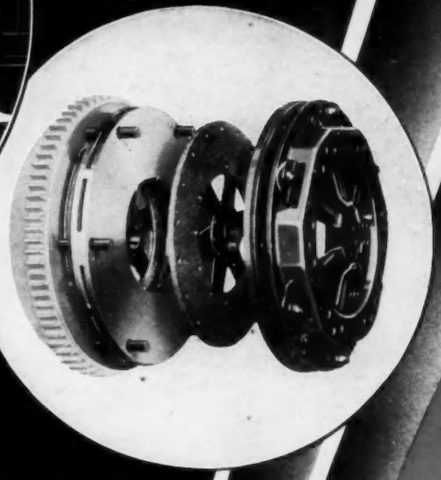
CLEVELAND·OHIO

LOS ANGELES·CALIF. · TORONTO·ONT.

# Another application for Long Clutches



ASANO BUSSAN
GASOLINE
RAIL CAR

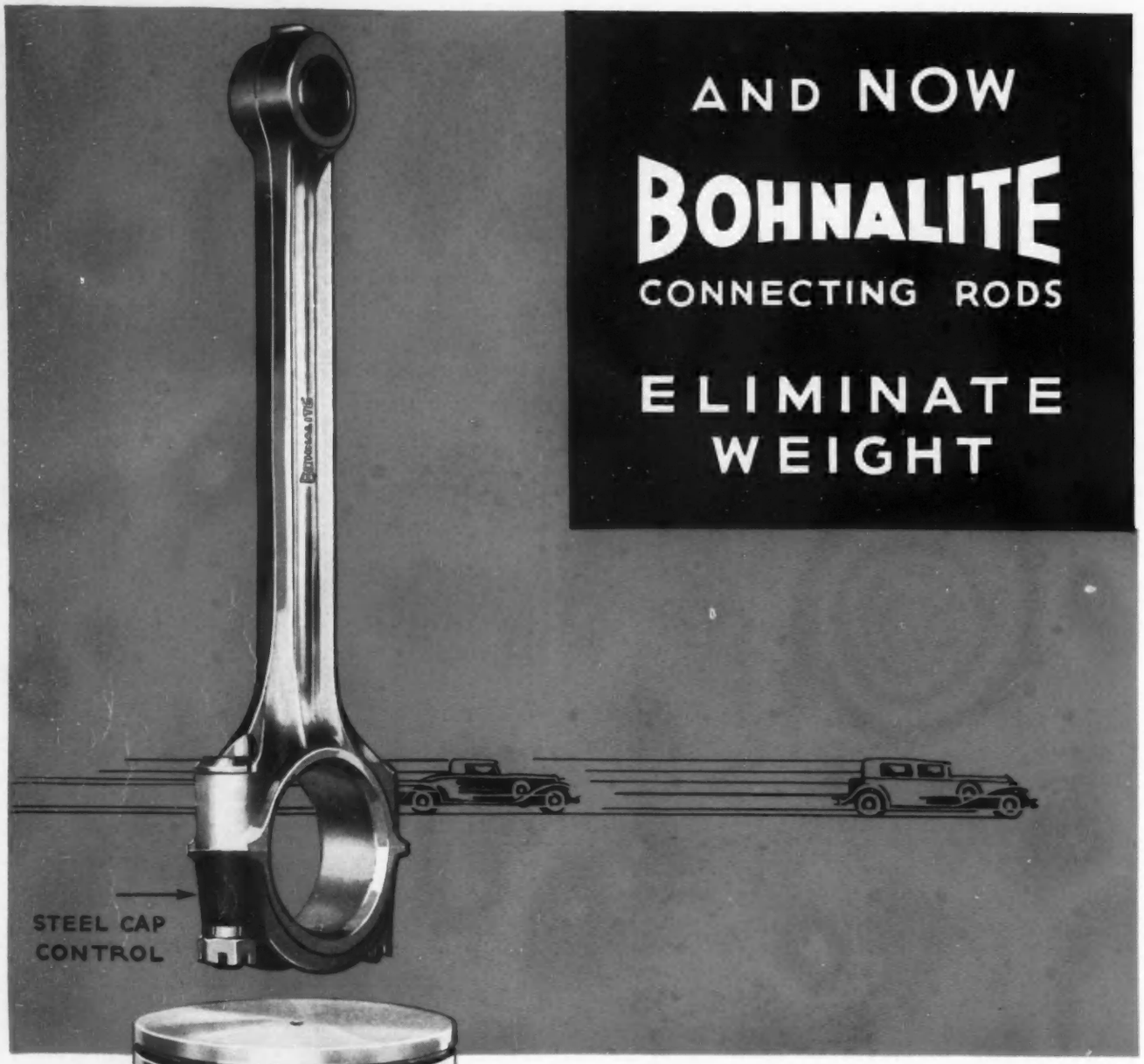


**LONG**

**LONG MANUFACTURING CO.**
DIVISION OF BORG-

**DETROIT, MICHIGAN**
WARNER CORPORATION

**AUTOMOTIVE CLUTCHES, RADIATORS, GRILLES**




# AND NOW
# BOHNALITE
## CONNECTING RODS
# ELIMINATE WEIGHT

NELSON
**BOHNALITE**
PISTONS

Just as Nelson Bohnalite Pistons were a great step forward in developing engine performance, so Bohnalite Connecting Rods are a still further step in securing better engine performance.

Bohnalite—the new light alloy which is 62% lighter than iron, makes possible a weight reduction in reciprocating parts not possible with the old steel rods.

And probably most important of all is the specially designed Bohn Steel Cap Control. This feature overcomes the last objection to light alloy rods, for its adoption means that oil clearances are maintained constant at all temperatures.

Bearing loads are reduced 20% to 40% with the new Bohnalite Connecting Rods. Their heat-dissipating qualities also enable the engine bearings to operate at a much lower temperature. Together with Nelson Bohnalite Pistons, Bohnalite Rods form an ideal combination to obtain the highest efficiency in modern high speed engines.

In use for two years, Bohnalite Rods have fully demonstrated their superiority in actual service.

**BOHN ALUMINUM & BRASS CORP., DETROIT, MICHIGAN**
New York Chicago Cleveland Pittsburgh

UNSEEN, unheard, unthought-of, Borg & Beck Clutches travel millions and millions of miles daily, adding much to that dependability of performance which is taken for granted in the modern motor car.

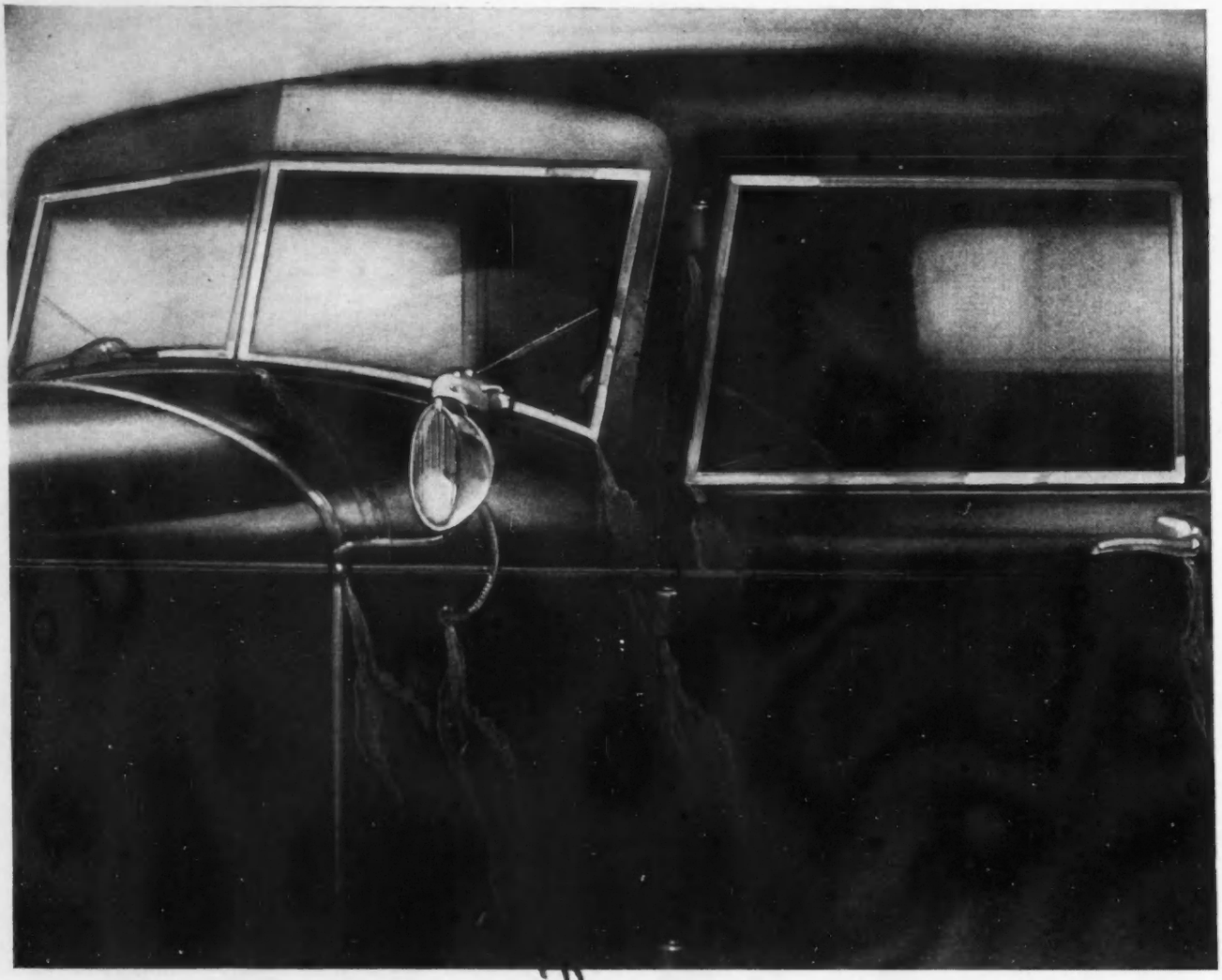
Borg & Beck Clutches are thoroughly proven engineering products, with a long record of successful service on cars of every price class. That is why so many automobile manufacturers use them as standard equipment.

THE BORG & BECK COMPANY
6558 South Menard Avenue CHICAGO, ILL.

# BORG & BECK

BORG & BECK CLUTCH · THE STANDARD

DIVISION OF
BORG-WARNER
CORPORATION



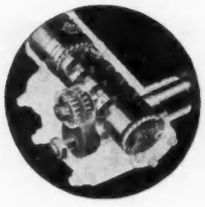
# THE RED FINGER POINTS

Don't guess where your cars need Stainless Trim. Just watch them on the road. See those red fingers of rust running down and ruining the paint—pointing out the places where plating or any other protective coating cannot last . . . Accusing fingers, reminding buyers of neglect in protecting the car against the quick depreciation which weather works. Here is an obvious use for "Stainless" and one which immediately effects sales . . . This modern metal is available in every commercial form and in a range of physical properties to suit every engineering and fabricating requirement. It is certainly true that if beautiful trim helps to sell a car, then trim which stays beautiful will help to keep it sold. Remember this and remember that "Stainless" costs less than other practical corrosion-resisting metals. Genuine Stainless Steel is manufactured only under the patents of American Stainless Steel Company, Commonwealth Building, Pittsburgh, Pennsylvania. Write for new booklet "Forward with Stainless" . . . today.

# STAINLESS STEEL

★

# Why Do 235 Engineering Staffs Choose ROSS?



They choose Ross Cam and Lever Steering, primarily, because it is *good steering*—steering in which ease, stability and instant response are properly balanced to meet the demands of modern, high-speed driving conditions.

In addition, they prefer Ross because excellence of design and manufacture, plus most accurate and accessible adjustments, maintain the original alignments and steering effects *for the life of the car.*

The Cam and Lever Steering Gear was developed, and is manufactured, *exclusively by Ross!* The steering advantages inherent in the cam-and-lever principle—the precision adjustments which assure life-long steering effects—*can be had in no other steering gear!*

It is only logical that more than 200 engineering staffs specify Ross to steer the vehicles which they design. Ross Cam and Lever Steering is standard equipment on *14* passenger cars, *113* trucks and buses, and *108* other motive-powered vehicles of various types.—*Ross Gear & Tool Company, Lafayette, Indiana.*

**ROSS CAM AND LEVER STEERING**

★

# IN 1932 FOUR LEADING CAR BUILDERS WILL STANDARDIZE

*on*

## THE HARRISON VISCON

The Harrison Viscon—oil temperature regulator—has proved its worth. It has passed the test of actual service in more than 200,000 cars now on the road.

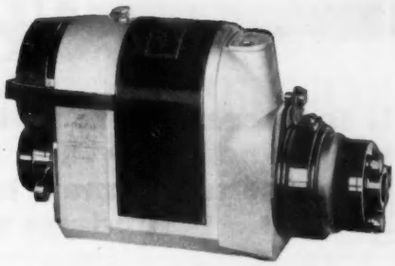
It has demonstrated its value to thousands of owners and to automotive engineers. Four manufacturers of quality cars will use the Viscon on 12 different models for 1932, thus insuring more uniform oil temperature the year 'round. If you are interested in greater lubricating efficiency, call in a Viscon engineer.

PRODUCT OF
**HARRISON RADIATOR CORPORATION**
LOCKPORT, NEW YORK

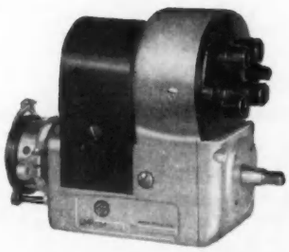
# BOSCH

## ROBERT BOSCH A.G.

The two names that stand out above all others in magneto ignition are the Bosch Super-Energy Magneto and the American Bosch High Tension Magneto. These two products have been recognized universally and accepted throughout the world for their dependability, the excellence of their performance, design and manufacture.



BOSCH FU 4 MAGNETO WITH IMPULSE COUPLING



AMERICAN BOSCH U 4 MAGNETO

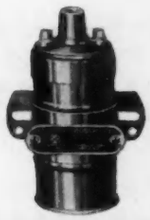
Everywhere the finest engines built are equipped with magnetos carrying the names of Bosch or American Bosch.

Longer life, better service and greater efficiency are built into these magnetos as is every engineering improvement and advancement that will assure better performance.

# AMERICAN - BOSCH -

BOSCH *Pyro-Action* SPARK PLUG

AMERICAN BOSCH HIGH TENSION IGNITION COIL



PRODUCTS OF ROBERT BOSCH A. G. STUTTGART, GERMANY. SOLD BY

PRODUCTS OF AMERICAN BOSCH MANUFACTURED BY

## UNITED AMERICAN BOSCH CORPORATION

SPRINGFIELD, MASS. *Branches:* NEW YORK CHICAGO DETROIT SAN FRANCISCO

CANADIAN WAREHOUSE: TORONTO, CANADA

# ROLLWAY BEARING COMPANY INCORPORATED

SYRACUSE — ROLLWAY CYLINDRICAL ROLLER BEARINGS — NEW YORK

**It is interesting to reflect that even the startling and consistently maintained growth in the use of Rollway bearings by automobile manufacturers may be explained in terms of three simple fundamentals: Product—Service—Price.**

## YOUR TUBING PROBLEM?

Have you an infrequent operation—or a too costly part—or need a new design? Perhaps we can find your answer. Get our prices—on lengths, coils or fabricated parts.

**WOLVERINE TUBE CO.**

SEAMLESS COPPER — BRASS & ALUMINUM

1445 Central Ave. — Detroit, Mich.

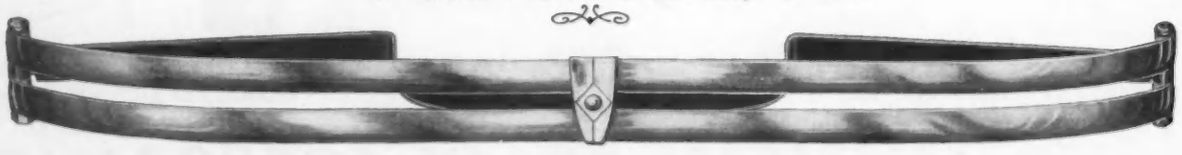
Sales Offices: Cleveland; Chicago; Atlanta; Los Angeles; Denver; Dayton, Ohio; New York City; Dallas, Texas

## HAVE YOU A NEW ADDRESS?

*If you have moved please notify the office of the Society so that you will not miss an issue of your Journal.*

## STANDARD STEEL SPRING CO.

CORAOPOLIS, PA.



Springs and Bumpers

# FELT
## The Versatile Product

AMERICAN FELT COMPANY, largest Felt manufacturers in the world, would gladly cooperate with your engineers in solving the most difficult problems. The diversified uses of Felt are really amazing.

Our complete and modern Felt Cutting Plant at Detroit, as well as our five Felt Mills, has provided the Automotive Industry with an entirely dependable source of supply. We are fully equipped to supply Felt in bulk or cut to the most exacting specifications.

**American Felt Company**
TRADE MARK

General Offices
315—4th Ave., New York

Boston Chicago Philadelphia
Detroit San Francisco St. Louis

# 2 Leaders

## PIERCE GOVERNOR

For years the leader in sensitivity and dependability. Instant response to all load variations. Built with quick speed change or positively sealed.

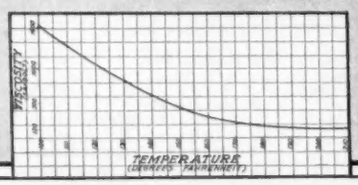
## SISSON AUTOMATIC CHOKE

This ends wasteful, inefficient hand choking; flooded carburetors, wasted gasoline. Just step on the starter and get automatic and accurate choking!

*Write for Catalog "S"*

PIERCE GOVERNOR CO.
ANDERSON, IND.

*Have you seen the* **GULFPRIDE** *charts?*




# VISCOSITY!

Have you seen the viscosity curves of Gulfpride Oil, plotted point by point through a whole range of temperatures?

You will find these curves practically duplicate those of vegetable castor oils. Yet Gulfpride Oil avoids castor's gum- and carbon-forming characteristics.

Charts of Gulfpride qualities and performance have caused many automotive engineers to make their own tests. We shall be glad to cooperate with you, supplying any necessary data. Write, please.

GULF

GULF REFINING COMPANY
*General Sales Offices*
Pittsburgh, Pa., U. S. A.

*Gulfpride Oil*

• AMERICA'S FINEST MOTOR OIL •

# Simplify and Save
## We Can Save You Money

Have helped many manufacturers cut costs by simplifying their stamped parts or by replacing small castings with stampings.

On any parts of wire or sheet metal—stamped, shaped, soldered, riveted or welded we have the men, machinery, experience and habit of giving unusual service to our customers.

Send us samples and blueprints. Get our suggestions and prices.

## THE AKRON-SELLE CO.
*"46 Years in Business"*
Akron, Ohio

# INDEX TO ADVERTISERS' PRODUCTS

**Absorbers, Shock**
Delco Products Corp.
Monroe Auto Equipment Co.
Watson Co., John Warren

**Acids**
New Jersey Zinc Co.

**Acid, Chromic**
Vanadium Corp. of America

**Alloys, Alumino-Vanadium**
Vanadium Corp. of America

**Alloys, Babbitt**
Federal-Mogul Corp.

**Alloys, Cupro-Vanadium**
Vanadium Corp. of America

**Alloys, Ferro-Chrome**
Vanadium Corp. of America

**Alloys, Ferro-Molybdenum**
Vanadium Corp. of America

**Alloys, Ferro-Silicon**
Vanadium Corp. of America

**Alloys, Ferro-Spiegeleisen**
New Jersey Zinc Co.

**Alloys, Ferro-Tungsten**
Vanadium Corp. of America

**Alloys, Ferro-Vanadium**
Vanadium Corp. of America

**Alloys, Magnesium**
Dow Chemical Co.

**Alloys, Silico-Manganese**
Vanadium Corp. of America

**Alloys, Zinc**
New Jersey Zinc Co.

**Alloys, Zinc Base Die Casting**
New Jersey Zinc Co.

**Ammeters**
A C Spark Plug Co.
General Electric Co.

**Anti-Freeze Solution**
National Carbon Co., Inc.

**Anti-Rust Solution**
National Carbon Co., Inc.

**Apparatus, Ignition**
General Electric Co.

**Axles, Rear, Motor-Truck**
Park Drop Forge Co.

**Balls, Steel**
New Departure Mfg. Co.

**Bands, Steel**
Bethlehem Steel Co.

**Bars, Bronze**
Federal-Mogul Corp.

**Batteries, Dry—Radio, Flashlight, Ignition**
National Carbon Co., Inc.

**Batteries, Farm Lighting**
Willard Storage Battery Co.

**Batteries, Storage**
Willard Storage Battery Co.

**Bearings, Babbitt and Bronze**
Federal-Mogul Corp.

**Bearings, Babbitt Metal**
Federal-Mogul Corp.

**Bearings, Ball, Angular Contact type**
Bearings Co. of America
New Departure Mfg. Co.
S K F Industries, Inc.
Strom Bearings Co.

**Bearings, Ball, Annular, Light, Medium and Heavy Series**
Federal Bearings Co., Inc.
New Departure Mfg. Co.
Norma-Hoffmann Bearings Corp.
S K F Industries, Inc.
Strom Bearings Co.

**Bearings, Ball, Thrust**
Bearings Co. of America
Norma-Hoffmann Bearings Corp.
S K F Industries, Inc.
Strom Bearings Co.

**Bearings, Die-Cast**
Federal-Mogul Corp.

**Bearings, Line Shaft**
Link-Belt Co.
S K F Industries, Inc.

**Bearings, Roller**
Hyatt Roller Bearing Co.
Norma-Hoffmann Bearings Corp.
Rollway Bearing Co., Inc.
S K F Industries, Inc.

**Bearings, Roller Radial**
Rollway Bearing Co., Inc.
Timken Roller Bearing Co.

**Bearings, Roller, Thrust**
Rollway Bearing Co., Inc.
Timken Roller Bearng Co.

**Bearings, Tapered Roller**
Timken Roller Bearing Co.

**Blanks, Gear**
Akron-Selle Co.
Bethlehem Steel Co.
Link-Belt Co.
Morse Chain Co.
Park Drop Forge Co.
Republic Steel Corp.
Wyman-Gordon Co.

**Blanks, Sprocket**
Akron-Selle Co.

**Bodies, Steel**
Budd Mfg. Co., E. G.

**Bolts**
Columbus Bolt Works Co.
Thompson Products, Inc.

**Brake Drums**
Bethlehem Steel Co.
Kelsey-Hayes Wheel Corp.

**Brake-Hose Assemblies, Hydraulic**
Hydraulic Brake Co.

**Brake-Lining**
Multibestos Co.

**Brakes, Air**
Bendix-Westinghouse Automotive Air Brake Co.
General Electric Co.

**Brakes, Mechanical**
Bendix Brake Co.
Kelsey-Hayes Wheel Corp.

**Bumpers, Passenger Car**
Standard Steel Spring Co.

**Bumpers, Truck**
Standard Steel Spring Co.

**Bushings, Babbitt**
Federal-Mogul Corp.

**Bushings, Bronze**
Federal-Mogul Corp.

**Bushings, Steel**
Thompson Products, Inc.

**Cable, Insulated**
American Steel & Wire Co.
Kerite Insulated Wire & Cable Co., Inc.

**Cadmium**
New Jersey Zinc Co.

**Camshafts**
Park Drop Forge Co.
Wyman-Gordon Co.

**Caps, Tank**
Akron-Selle Co.

**Castings, Babbitt Metal**
Federal-Mogul Corp.

**Castings, Bronze**
Federal-Mogul Corp.

**Castings, Die**
A C Spark Plug Co.
Federal-Mogul Corp.

**Castings, Magnesium Alloy**
Dow Chemical Co.

**Castings, Grey Iron**
Link-Belt Co.
Timken Roller Bearing Co.

**Castings, Steel**
Clark Equipment Co.
Link-Belt Co.

**Castings, Tin Alloy**
Federal-Mogul Corp.

**Chains, Block**
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

**Chains, Roller**
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

**Chains, Silent**
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

**Chains, Timing and Automatic Adjustments**
Link-Belt Co.
Morse Chain Co.

**Chokes**
Pierce Governor Co.

**Clamps, Hose**
Schrader's Son, Inc., A.

**Cleaners, Air**
A C Spark Plug Co.

**Clutches, Automotive**
Borg & Beck Co.
Brown-Lipe Gear Co.
Long Mfg. Co.
Spicer Mfg. Corp.

**Clutches, Industrial**
Link-Belt Co.

**Coils, Ignition**
United American Bosch Corp.

**Compressors, Air**
Curtis Pneumatic Machinery Co.
General Electric Co.

**Conduits, Flexible, Non-Metallic**
General Electric Co.

**Connecting-Rods, Aluminum**
Bohn Aluminum & Brass Corp.

**Connections, Tire-Pump**
Schrader's Son, Inc., A.

**Control Sets, Automotive**
Brown-Lipe Gear Co.

**Cooling Systems**
G & O Mfg. Co.
Long Mfg. Co.

**Couplings, Tubing**
Dole Valve Co.

**Couplings, Flexible**
Link-Belt Co.
Morse Chain Co.
Spicer Mfg. Corp.

**Cranes, Pneumatic**
Curtis Pneumatic Machinery Co.

**Cranks, Starting**
Thompson Products, Inc.
Kelsey-Hayes Wheel Corp.

**Crankshafts**
Park Drop Forge Co.
Wyman-Gordon Co.

**Cups, Grease**
Link-Belt Co.

**Cutters, Woodruff**
Whitney Mfg. Co.

**Deflectors, Draft**
Dole Valve Co.

**Diesel Engine Injection Pumps and Nozzles**
United American Bosch Corp.

**Differentials**
New Process Gear Co., Inc.

**Discs, Clutch, Steel**
Curtis Pneumatic Machinery Co.

**Drop-Forgings**
Bethlehem Steel Co.
Columbus Bolt Works Co.
Park Drop Forge Co.
Spicer Mfg. Corp.
Wyman-Gordon Co.

**Durometers**
Shore Instrument & Mfg. Co.

**Dynamometers, Chassis**
General Electric Co.

**Dynamometers, Engine**
General Electric Co.

**Engines**
Continental Motors Corp.
Waukesha Motor Co.

**Engines, Industrial**
Waukesha Motor Co.

**Equipment, Arc-Welding**
General Electric Co.

**Facings, Clutch**
Multibestos Co.

**Fans, Electric**
Delco Appliance Corp.

**Felloe-Bands, Motor-Truck, Pneumatic Tire**
Motor Wheel Corp.
Kelsey-Hayes Wheel Corp.

**Felt**
American Felt Co.

**Filters, Oil**
A C Spark Plug Co.

**Flashlights**
National Carbon Co., Inc.

**Forgings, Magnesium Alloy**
Dow Chemical Co.

**Furnace, Automatic Electric**
General Electric Co.

**Fuses, Electric**
General Electric Co.

**Gages, Gasoline**
A C Spark Plug Co.
Akron-Selle Co.

**Gages, Oil**
A C Spark Plug Co.
Akron-Selle Co.

**Gages, Thermo**
A C Spark Plug Co.

**Gages, Tire Pressure**
Schrader's Son, Inc., A.

**Gas Electric Drive**
General Electric Co.

**Gas Systems**
Delco Appliance Corp.

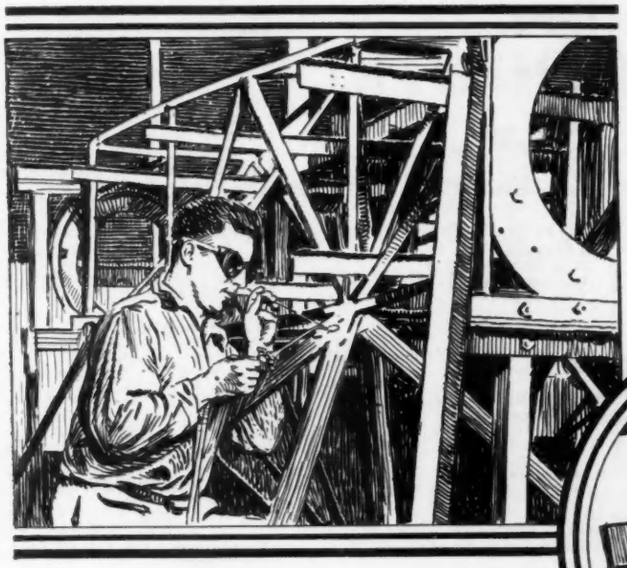
(*Continued on page 60*)

## Manufacturers of Products Conforming to S.A.E. Specifications

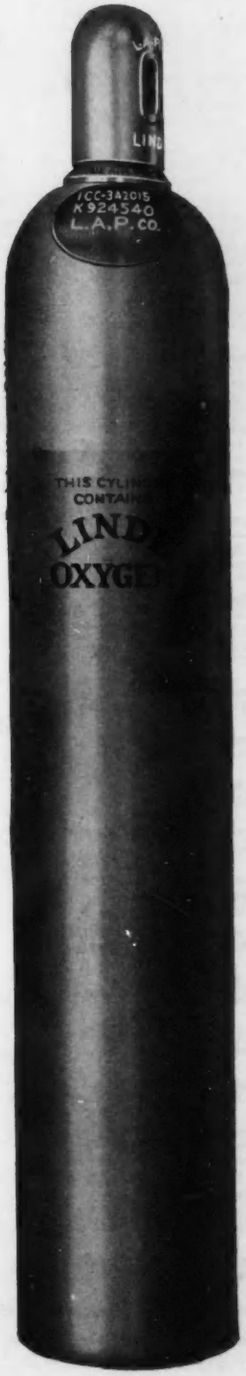
Advertisers whose products conform to S.A.E. specifications are also listed in the S.A.E. Handbook List of Manufacturers, beginning on page 675, of the 1931 issue of the Handbook.

The addresses of companies listed in this index can be obtained from their current advertisements indexed on page 64.

# From simple joints to complex designs



## LINDE PROCESS SERVICE ASSURES DEPENDABLE WELDS




LINDE PROCESS SERVICE frequently suggests methods that mark the turning point from uncertain production costs and possible losses to certain profits.

Whether the problem is one of simple joining or intricate fabrication, Linde Process Service offers you, if you use Linde Oxygen, every facility for the most effective use of oxy-acetylene welding and cutting. This service, with its unequalled background of scientific research and practical experience, is readily coordinated with the work of your own engineers and welders in securing maximum speed, economy and dependability. For example:

It assisted a manufacturer of laundry equipment in obtaining ideal joints in sheet metal for vitreous enameling. The joints produced are strong enough to withstand the strains of the enameling process and so smooth as to become invisible.

It helped a chemical plant in developing corrosion resisting welds in aluminum pipe coils used in rosin manufacture.

It developed procedure controls for aircraft welding, including specialized training and severe qualification tests for the welders and careful inspection of every detail of the work.

These examples illustrate but a few of the many benefits Linde customers constantly receive from Linde Process Service. Consult the nearest Linde District Office for further facts showing how oxwelding and cutting under Linde Procedure Control can be of immediate benefit to you.

**THE LINDE AIR PRODUCTS COMPANY**

*Unit of Union Carbide and Carbon Corporation*

126 Producing Plants UCC 627 Warehouse Stocks

IN CANADA, DOMINION OXYGEN COMPANY, LTD., TORONTO

District Offices

| | | |
|---|---|---|
| Atlanta | Detroit | New York |
| Baltimore | El Paso | Philadelphia |
| Birmingham | Houston | Pittsburgh |
| Boston | Indianapolis | St. Louis |
| Buffalo | Kansas City | Salt Lake City |
| Chicago | Los Angeles | San Francisco |
| Cleveland | Milwaukee | Seattle |
| Denver | Minneapolis | Tulsa |

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES • UNION CARBIDE

# INDEX TO ADVERTISERS' PRODUCTS

**Gasoline, Aircraft**
Gulf Refining Co.
Texas Company, The

**Gasoline, Motor Vehicle**
Ethyl Gasoline Corp.
Gulf Refining Co.
Texas Company, The

**Gearboxes, Power Take-Off**
Brown-Lipe Gear Co.

**Gears, Bevel**
Brown-Lipe-Chapin Co.
Link-Belt Co.
Park Drop Forge Co.

**Gears, Composition**
General Electric Co.

**Gears, Differential**
Brown-Lipe-Chapin Co.
New Process Gear Co., Inc.
Park Drop Forge Co.

**Gears, Fibre**
General Electric Co.

**Gears, Reduction**
Link-Belt Co.
Morse Chain Co.
Waukesha Motor Co.

**Gears, Spur**
Link-Belt Co.

**Gears, Steel**
Link-Belt Co.

**Gears, Steering**
Gemmer Mfg. Co.
Ross Gear & Tool Co.

**Gears, Timing**
General Electric Co.

**Gears, Transmission**
Link-Belt Co.
Park Drop Forge Co.
Wyman-Gordon Co.

**Generating Plants, Gas Driven**
Delco Appliance Corp.

**Generators**
United American Bosch Corp.

**Generators (Standard Mountings)**
Electric Auto-Lite Co.
General Electric Co.

**Glass, Safety**
Libbey-Owens-Ford Glass Co.

**Governors**
Pierce Governor Co.

**Greases**
Texas Company, The

**Greases, Cup**
Gulf Refining Co.

**Greases, Graphite**
Gulf Refining Co.

**Greases, High Pressure**
Gulf Refining Co.

**Greases, Precision**
Gulf Refining Co.

**Heaters, Automobile**
Delco Appliance Corp.

**Hoists, Air**
Curtis Pneumatic Machinery Co.

**Hoists, Electric**
General Electric Co.

**Horns, Electric**
United American Bosch Corp.

**Housings, Axle**
Park Drop Forge Co.
Pittsburgh Steel Products Co.

**Hubs, Wheel**
Budd Wheel Co.
Kelsey-Hayes Wheel Corp.

**Ignition Apparatus**
Delco Appliance Corp.

**Instruments, Precision Measuring**
Norma-Hoffmann Bearings Corp.

**Instruments, Scientific**
Shore Instrument & Mfg. Co.

**Insulation, Electric**
General Electric Co.

**Joints, Ball-and-Socket**
Thompson Products, Inc.

**Joints, Universal**
Spicer Mfg. Corp.

**Keys, Woodruff**
Whitney Mfg. Co.

**Lamps, Electric Incandescent**
General Electric Co.
National Carbon Co., Inc.

**Lifts, Automobile**
Curtis Pneumatic Machinery Co.

**Links, Drag**
Thompson Products, Inc.

**Lubricants**
Texas Company, The

**Lubricants, Transmission**
Gulf Refining Co.

**Lubricating Systems**
Alemite Mfg. Co.

**Machines, Power Transmission**
Link-Belt Co.
Morse Chain Co.

**Magnesium**
Dow Chemical Co.

**Magnetos**
United American Bosch Corp.

**Manifolds, Oxygen**
Linde Air Products Co.

**Metal, Monel**
International Nickel Co.

**Molybdenum, Metallic**
Vanadium Corp. of America

**Motors, Electric**
Delco Products Corp.

**Nails**
American Steel & Wire Co.
Jones & Laughlin Steel Corp.

**Nickel**
International Nickel Co.

**Nuts**
Columbus Bolt Works Co.
Kelsey-Hayes Wheel Corp.

**Oils, Aircraft**
Gulf Refining Co.

**Oils, Cleaning**
Gulf Refining Co.

**Oils, Lubricating**
Gulf Refining Co.

**Oils, Penetrating**
Gulf Refining Co.

**Ovens, Electric**
General Electric Co.

**Oxygen**
Linde Air Products Co.

**Panels, Instrument**
A C Spark Plug Co.

**Pinions**
General Electric Co.

**Pinions, Starting-Motor**
Electric Auto-Lite Co.

**Pins, King**
Thompson Products, Inc.

**Pins, Piston**
Thompson Products, Inc.

**Piston-Rings**
Piston Ring Co.

**Pistons, Aluminum**
Bohn Aluminum & Brass Corp.

**Powerplants, Industrial**
Waukesha Motor Co.

**Power Take-Offs**
Brown-Lipe Gear Co.

**Primers**
Dole Valve Co.

**Propeller-Shafts**
Spicer Mfg. Corp.

**Pumps, Fuel**
A C Spark Plug Co.

**Pyroscopes**
Shore Instrument & Mfg. Co.

**Radiators**
G & O Mfg. Co.
Harrison Radiator Corp.
Long Mfg. Co.

**Radio**
United American Bosch Corp.

**Regulators, Acetylene and Oxygen**
Linde Air Products Co.

**Retainers, Ball**
Bearings Co. of America

**Rims, Airplane Tire**
Kelsey-Hayes Wheel Corp.

**Rims, Pneumatic Tire**
Kelsey-Hayes Wheel Corp.
Motor Wheel Corp.

**Rings, Welded Steel**
Akron-Selle Co.

**Rivets, Steel**
Columbus Bolt Works Co.

**Rod, Brake**
Thompson Products, Inc.

**Rod-Ends**
Columbus Bolt Works Co
Thompson Products, Inc.

**Rod, Tie**
Thompson Products, Inc.

**Rod, Magnesium Alloy**
Dow Chemical Co.

**Rod, Torque**
Thompson Products, Inc.

**Roller Bearings (See Bearings, Roller)**

**Roofing and Siding, Corrugated and Plain**
New Jersey Zinc Co.

**Roofing and Siding, Zinc Alloy**
New Jersey Zinc Co.

**Scleroscopes**
Shore Instrument & Mfg. Co.

**Screw-Machine Products**
Akron-Selle Co.
Barnes Co., Wallace
Link-Belt Co.
New Process Gear Co., Inc.
Spicer Mfg. Corp.

**Shafts, Propeller**
Pittsburgh Steel Products Co.
Spicer Mfg. Corp.

**Sheets, Magnesium Alloy**
Dow Chemical Co.

**Sheets, Steel**
Sharon Steel Hoop Co.

**Shutters, Radiator**
Pines Winterfront Co.

**Silencers, Carburetor Intake**
A C Spark Plug Co.

**Spark Plugs**
A C Spark Plug Co.
United American Bosch Corp.

**Speed Reducers**
Link-Belt Co.
Morse Chain Co.

**Speedometers**
A C Spark Plug Co.
Delco Appliance Corp.
Motor Wheel Corp.

**Spokes, Wood, Motor Truck**
Kelsey-Hayes Wheel Corp.
Motor Wheel Corporation

**Spokes, Wood, Passenger Car**
Kelsey-Hayes Wheel Corp.
Motor Wheel Corporation

**Springs, Coiled**
American Steel & Wire Co.
Barnes-Gibson-Raymond, Inc.
Cook Spring Co. Division
Gibson Co., Wm. D.

**Springs, Flat**
American Steel & Wire Co.
Barnes Co., Wallace
Barnes-Gibson-Raymond, Inc.
Cook Spring Co. Division
Gibson Co., Wm. D.

**Springs, Leaf**
Standard Steel Spring Co.

**Sprockets, Block Chain**
Morse Chain Co.
Whitney Mfg. Co.

**Sprockets, Roller-Chain**
Link-Belt Co.
Whitney Mfg. Co.

**Sprockets, Silent-Chain**
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

**Stampings**
Akron-Selle Co.
Barnes Co., Wallace
Cook Spring Co. Division
Kelsey-Hayes Wheel Corp.
Motor Wheel Corp.
Spicer Mfg. Corp.

**Stands, Tire Inflating**
Curtis Pneumatic Machinery Co.

**Starting Motors**
United American Bosch Corp.

**Starting-Motor (Standard Mountings)**
Electric Auto-Lite Co.

**Steel Alloy**
American Steel & Wire Co.
Bethlehem Steel Co.
Republic Steel Corp.
Timken Roller Bearing Co.

**Steel, Carbon**
Barnes Co., Wallace
Bethlehem Steel Co.
Jones & Laughlin Steel Corp.
Republic Steel Corp.
Timken Roller Bearing Co.

**Steel, Chromium**
American Steel & Wire Co.
Bethlehem Steel Co.

**Steel, Chromium Vanadium**
Bethlehem Steel Co.

**Steel, Cold Drawn**
American Steel & Wire Co.
Jones & Laughlin Steel Corp.

**Steel, Electric Furnace**
Bethlehem Steel Co.
Link-Belt Co.
Timken Roller Bearing Co.

**Steel, Leaf Spring**
Republic Steel Corp.

**Steel, Molybdenum**
Republic Steel Corp.

**Steel, Nickel**
Bethlehem Steel Co.

**Steel, Non-Corrosive**
American Steel & Wire Co.
Bethlehem Steel Co.
Sharon Steel Hoop Co.

**Steel, Open Hearth**
Bethlehem Steel Co.
Jones & Laughlin Steel Corp.
Timken Roller Bearing Co.

(*Continued on page* 62)

# SHOULD *Automotive Engineers* design Automobiles?

**And isn't it logical that genuine Alemite Lubricants should be used in the Alemite Lubrication Systems on these automobiles?**

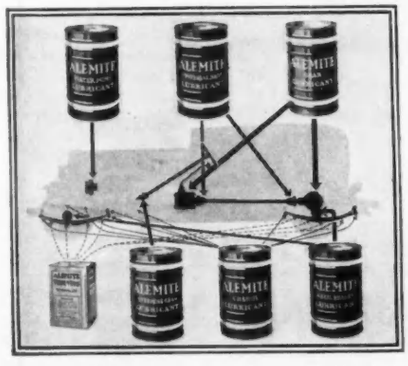
**Alemite's battle against the evils of "hit-or-miss greasing" should also be the battle of automotive engineers.**

*When more than 95% of America's great automotive engineers adopt the same system of lubrication on their cars, the efficiency of that system is unquestionable. This is the position which Alemite High Pressure Lubrication Systems have held for years.*

UNDER HUNDREDS OF POUNDS OF PRESSURE FRESH ALEMITE LUBRICANT IS FORCED INTO THE BEARINGS

Alemite has spent millions of dollars educating the motoring public on the subject of proper car lubrication. That has meant much in increasing the efficiency, long life and freedom from care in cars.

One of the greatest dangers which car manufacturers and designers must face is that of improper, careless use of just any old grease. To combat this evil, Alemite developed genuine Alemite Lubricants, especially designed for use in the Alemite System—a special type of lubricant for each special need in a car's chassis. Carefully chosen service dealers have been designated by Alemite as being capable of properly Alemite-ing a car. These dealers have been identified by the yellow Alemite sign.




SPECIAL ALEMITE LUBRICANTS FOR EACH SPECIAL NEED RESULT IN ESPECIALLY FINE CAR PERFORMANCE AND LOW UPKEEP

Naturally you are anxious to see every buyer of your cars receive all the fine performance and economy that you have built into them. That means that these cars must be regularly and properly lubricated.

Alemite offers car manufacturers a proved plan that meets this situation. Complete details will be sent to you on request. Address Alemite Corporation (Division of Stewart-Warner), 2654 N. Crawford Avenue, Chicago, Illinois.

# INDEX TO ADVERTISERS' PRODUCTS

**Steel, Rivet**
Bethlehem Steel Co.

**Steel, Special Analysis**
Timken Roller Bearing Co.

**Steel, Strip**
Sharon Steel Hoop Co.

**Steel, Tool**
Bethlehem Steel Co.
Timken Roller Bearing Co.

**Steel, Turned and Ground**
Jones & Laughlin Steel Corp.

**Steel, Turned and Polished**
Jones & Laughlin Steel Corp.

**Strainers, Gasoline**
A C Spark Plug Co.

**Studs, Ball**
Thompson Products, Inc.

**Switches**
United American Bosch Corp.

**Switches, Starting**
Electric Auto-Lite Co.

**Tape, Insulated**
Kerite Insulated Wire & Cable Co.

**Tappets**
Thompson Products, Inc.

**Terminals**
Douglas Mfg. Co., H. A.

**Testers, Hardness**
Shore Instrument & Mfg. Co.

**Thermostats**
Dole Valve Co.

**Timer-Distributors**
Electric Auto-Lite Co.

**Tires, Pneumatic**
Goodyear Tire & Rubber Co., Inc.

**Tires, Solid**
Goodyear Tire & Rubber Co., Inc.

**Torsion-Rod Assemblies**
Thompson Products, Inc.

**Transmissions**
Brown-Lipe Gear Co.

**Tubes, Torque**
Pittsburgh Steel Products Co.

**Tubes, Vacuum—Radio**
National Carbon Co., Inc.

**Tubing, Brass**
Bundy Tubing Co.

**Tubing, Copper**
Bundy Tubing Co.

**Tubing, Flexible Metal**
Chicago Tubing & Braiding Co.

**Tubing, Steel**
Bundy Tubing Co.

**Tubing, Steel, Seamless**
Pittsburgh Steel Products Co.
Timken Roller Bearing Co.

**Tungsten, Metallic**
Vanadium Corp. of America

**Universal-Joints**
Spicer Mfg. Corp.

**Valves, Poppet**
Thompson Products, Inc.

**Valves, Tire**
Schrader's Sons, Inc., A.

**Vanadium Pentoxide**
Vanadium Corp of America

**Washers, Automobile, Air and Hydraulic**
Curtis Pneumatic Machinery Co.

**Washers, Bronze**
Federal-Mogul Corp.

**Washers, Lock**
Shakeproof Lock Washer Co.

**Washers, Spring**
Barnes Co., Wallace

**Water Systems, Portable**
Delco Appliance Corp.

**Wheels, Metal**
Budd Wheel Co.
Kelsey-Hayes Wheel Corp.

**Wheels, Pressed Steel Disc**
Budd Wheel Co.
Kelsey-Hayes Wheel Corp.
Motor Wheel Corp.

**Wheels, Wire**
Budd Wheel Co.
Kelsey-Hayes Wheel Corp.

**Wheels, Wood**
Kelsey-Hayes Wheel Corp.
Motor Wheel Corp.

**Wicks, Felt**
American Felt Co.

**Windshield Wiper**
United American Bosch Corp.

**Wire Forms**
American Steel & Wire Co.
Barnes Co., Wallace

**Wire Products**
American Steel & Wire Co.
Barnes Co., Wallace
Jones & Laughlin Steel Corp.

**Zinc Alloys**
New Jersey Zinc Co.

**Zinc, Sheet**
New Jersey Zinc Co.

**Zinc, Slab**
New Jersey Zinc Co.

**Zinc, Stick**
New Jersey Zinc Co.

**Zinc, Strip**
New Jersey Zinc Co.

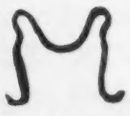
BGR INC

SPRINGS

Chances are even at any rate that you are getting good springs, promptly and dependably, now. If you would like to get better springs, or want a little more prompt delivery, or a more convenient source, tell us about it.

We believe we can be of real service to the engineer on spring design, and our facilities are at your disposal.

We are equipped to make all types of round wire and small flat springs of any material.



«Two Plants for Spring Service»

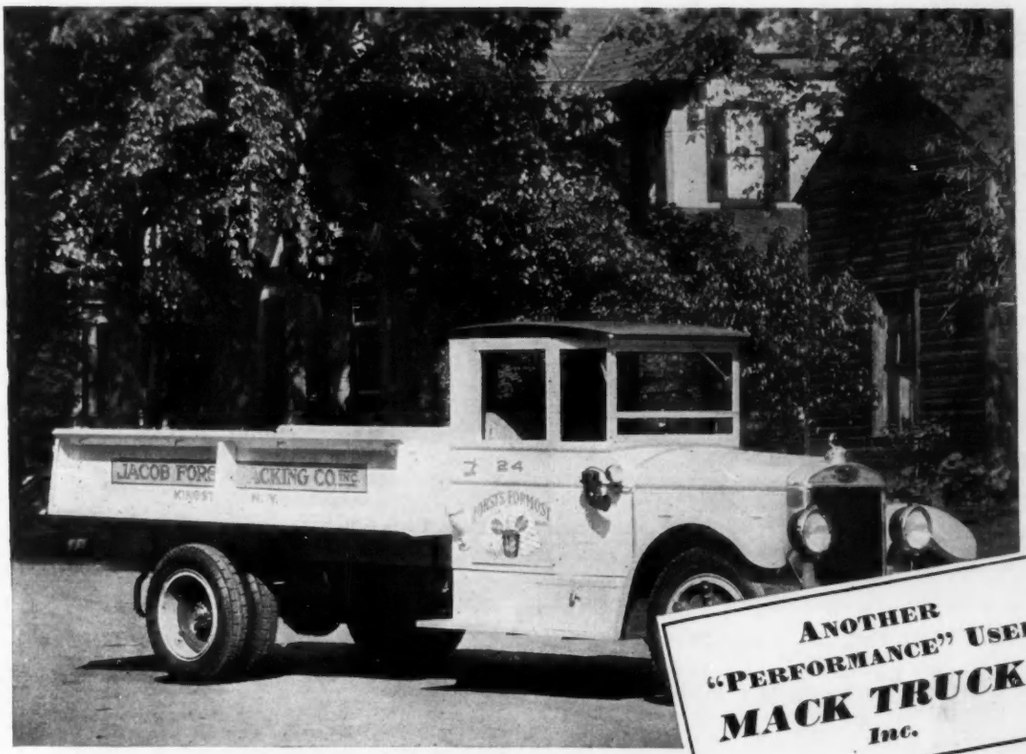
BGR INC.

DETROIT DIVISION
6400 MILLER AVENUE

COOK SPRING DIV'N
ANN ARBOR, MICH.

BARNES-GIBSON-RAYMOND-INC

# HIGHEST DEPENDABILITY PER MILE WITH SKF PERFORMANCE!




ANOTHER "PERFORMANCE" USER
MACK TRUCKS Inc.

## WHERE PERFORMANCE TAKES PREFERENCE OVER PRICE

*You may buy a bearing as a bargain but try and get a bargain out of using it, for nothing is apt to cost so much as a bearing that cost so little.*

High speed delivery work or long distance service at the lowest cost per mile . . . both call for the utmost mechanical efficiency in motor trucks. To insure such a high standard of operation continuously, Mack selected SKF Ball Bearings for important locations on their 57 H. P., 1½ ton truck.

SKF Ball Bearings contribute materially to performance that can be depended upon . . . rain or shine . . . under all conditions. They run quietly, need no adjustments, and add to the mileage of correlated parts. But most important of all is the long life of never-failing dependability that makes SKF Performance take Preference Over Price.

2775

SKF INDUSTRIES, INC. 40 EAST 34th STREET, NEW YORK, N. Y.

SKF

Ball and Roller Bearings

# INDEX TO ADVERTISERS


A

A C Spark Plug Co. ..... 13
Akron-Selle Co. ..... 57
Alemite Corp. ..... 61
American Felt Co. ..... 57
American Stainless Steel Co. ... 52
American Steel & Wire Co. ..... 2
American Telephone & Telegraph Co. ..... 29

B

Barnes Co., Wallace ..... 40
Barnes-Gibson-Raymond, Inc. ... 62
Bearings Co. of America ..... 26
Bendix Brake Co. Outside Back Cover
Bendix-Westinghouse Automotive Air Brake Co. ..... 14
Bethlehem Steel Co. ..... 30
Bohn Aluminum & Brass Corp. ... 50
Borg & Beck Co. ..... 51
Brown-Lipe Gear Co. ..... 24
Budd Mfg. Co., Edward G. ..... 23
Budd Wheel Co. ..... 25
Bundy Tubing Co. ..... 15

C

Columbus Bolt Works Co. ..... 38
Continental Motors Corp. ..... 42
Cook Spring Co. Division ..... 60
Curtis Clutch Disc Co. ..... 32

D

Delco Appliance Corp. ..... 33
Delco Products Corp. ..... 43
Dole Valve Co. ..... 22
Douglas Mfg. Co., H. A. ..... 47
Dow Chemical Co. ..... 5

E

Electric Auto-Lite Co. Inside Back Cover

F

Federal Bearings Co., Inc. ..... 6
Federal-Mogul Corp. ..... 1

G

G & O Mfg. Co. ..... 40
Gemmer Mfg. Co. ..... 7
General Electric Co. ..... 31
Gibson Co., Wm. D. ..... 38
Gulf Refining Co. ..... 57

H

Harrison Radiator Corp. ..... 54
Hyatt Roller Bearing Co. ..... 3

I

International Nickel Co., Inc. .... 46

J

Jones & Laughlin Steel Corp. .... 11

K

Kelsey-Hayes Wheel Corp. ..... 41
Kerite Insulated Wire & Cable Co., Inc. ..... 19

L

Libbey-Owens-Ford Glass Co. ..... 45
Linde Air Products Co. ..... 59
Link-Belt Co. ..... 66
Long Mfg. Co. ..... 49

M

Motor Wheel Corp. ..... 16

N

National Auto Shows ..... 39
New Departure Mfg. Co. ..... 65
New Jersey Zinc Co. ..... 44
New Process Gear Co., Inc. ..... 10
Norma-Hoffmann Bearings Corp. 28

P

Parish Pressed Steel Co. ..... 24
Park Drop Forge Co. ..... 34
Pierce Governor Co. ..... 57
Pines Winterfront Co. ..... 8
Piston Ring Co. ..... 21
Pittsburgh Steel Products Co. ... 4

R

Republic Steel Corp. ..... 34
Rollway Bearing Co., Inc. ..... 56
Ross Gear & Tool Co. ..... 53
Russell Mfg. Co. ..... 20

S

S K F Industries, Inc. ..... 63
Salisbury Axle Co. ..... 24
Shakeproof Lock Washer Co. ..... 9
Spicer Mfg. Corp. ..... 24
Standard Steel Spring Co. ..... 56
Stewart-Warner Corp. .....36, 37

T

Thompson Products, Inc. ..... 32
Timken Roller Bearing Co. ..... 35

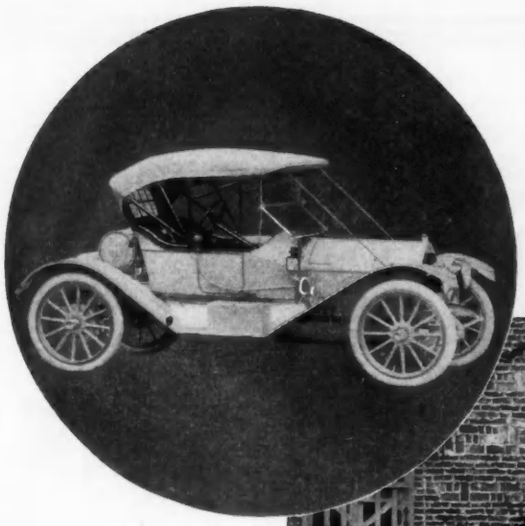
U

United American Bosch Corp. .... 55
United Chromium, Inc. ..... 27

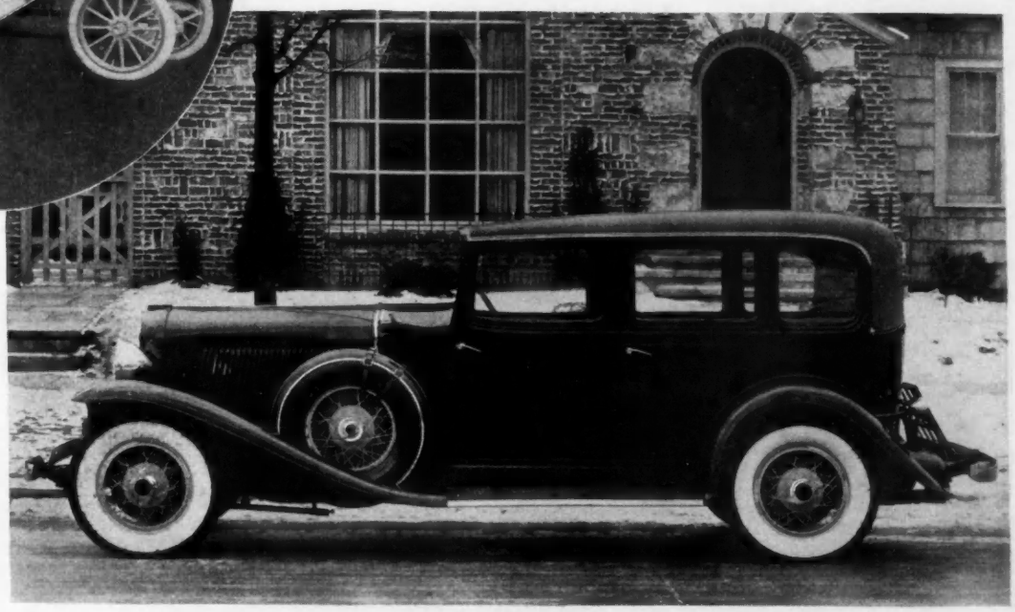
W

Watson Co., John Warren Inside Front Cover
Waukesha Motor Co. ..... 12
Whitney Mfg. Co. ..... 30
Willard Storage Battery Co. ..... 48
Wolverine Tube Co. ..... 56
Wyman Gordon Co. ..... 18

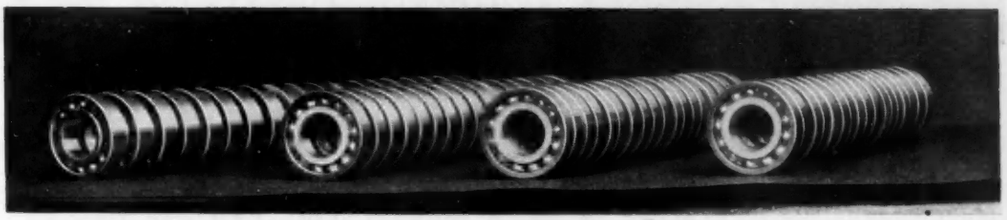

*The Index to Advertisers' Products is given on pages 58, 60 and 62*



# Twenty years forward . . . with Auburn



## New Departures all the way



There was a time when automobiles were a success if they were made to run. But Auburn early realized the importance of good bearings, among other things, if cars were to fulfill their ultimate mission in the scheme of things. Auburn designed New Departures into the 1911 model and has used them every year since. New Departures are vastly better than they were in 1911 . . . and so are Auburns, of course. Both were aiming high and both have come close to the bull's-eye. The New Departure Mfg. Co., Bristol, Connecticut; Branches at Detroit, Chicago, San Francisco, London.

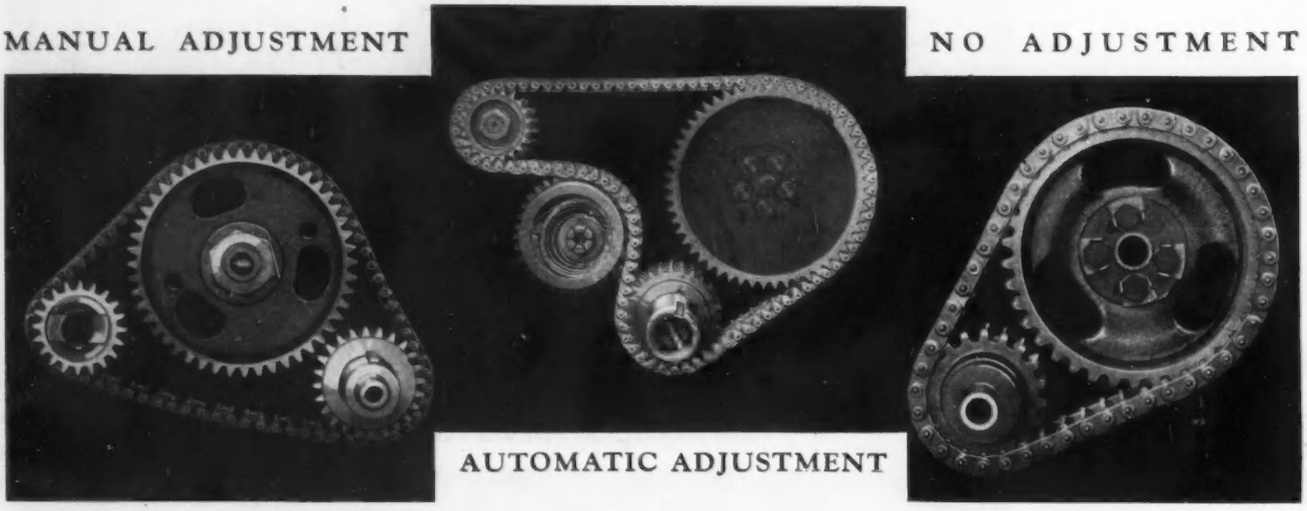
# New Departure Ball Bearings

1813

# "UNIVERSALLY APPROVED"

MANUAL ADJUSTMENT

NO ADJUSTMENT



AUTOMATIC ADJUSTMENT

WHETHER the most convenient and efficient layout calls for 2, 3, or more wheels, or for manual adjustment or automatic adjustment of chain tension, Link-Belt can furnish the type that suits the requirements best.

Our experienced engineers are at your service.

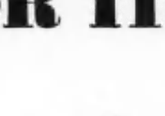
**LINK-BELT COMPANY**
**INDIANAPOLIS - - DETROIT**

# LINK-BELT

## AUTOMOTIVE SILENT CHAIN

4291

# RECOGNIZED EVERYWHERE FOR ITS FINE SERVICE STATIONS



The owner of an Auto-Lite equipped automobile knows that in whatever part of the country he may be, Auto-Lite service is available. He also knows that at official Auto-Lite stations he is sure of receiving the most satisfactory service and the high quality of Auto-Lite parts.

That motorists and automobile manufacturers recognize the extent and quality of Auto-Lite service facilities is evidenced by the fact that nearly half of all automobiles built are equipped with Auto-Lite starting, lighting and ignition systems.

The Electric Auto-Lite Company, Toledo, Ohio.

**Auto-Lite**

*Starting, Lighting & Ignition*

# BENDIX

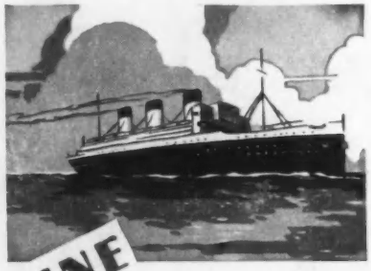
## PRODUCTS

● Bendix Brakes ● Stromberg Carburetors

● Bendix Drive ● B-K Vacuum Brake Boosters

● Eclipse Aircraft Starters and Generators

● Delco Aircraft Ignition ● Aircraft Propellers




● Bendix-Westinghouse Air Braking Systems

● Scintilla Magnetos ● Pioneer Instruments

● Marine Instruments ● Cowdrey Brake Testers

**NEW PRODUCTS**

● Bendix Automatic Clutch Control ● Bendix Startix

**BENDIX AVIATION CORPORATION**

**CHICAGO · NEW YORK**